9 1937

Engineering News-Record

McGraw-Hill Publishing Company, Inc. February 4, 1937 Twenty-five Cents, Five Dollars per Year

Annual Review Number

Construction Near Six Billion Dollars

Flood Control Begun

Grade-Crossing Elimination

Status of Major Projects

Forecasting Floodflows

Engineering Knowledge and Practice

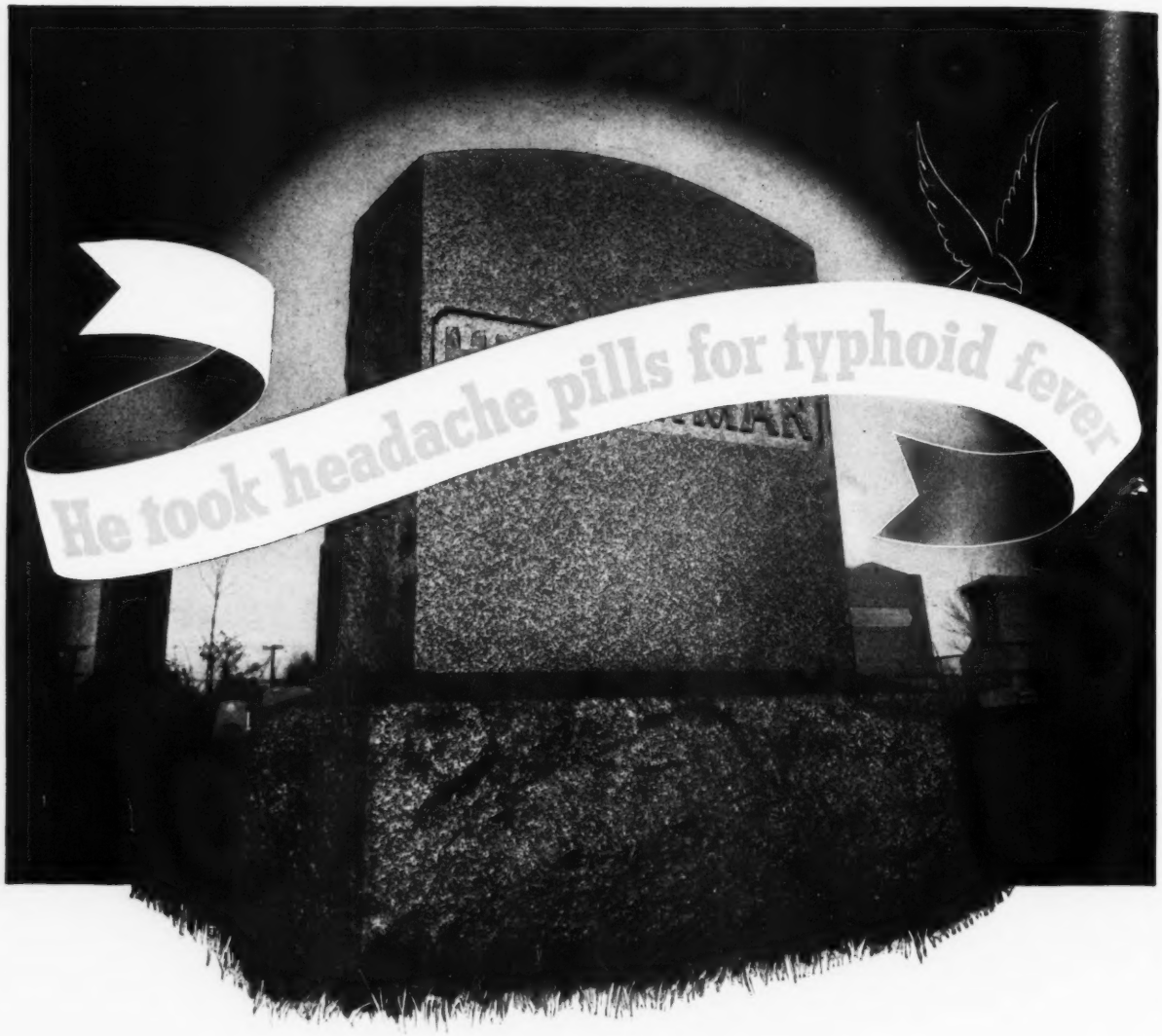
A Record of Drought and Floods

A Group of Staff Reviews and Special Articles by

GEORGE B. PILLSBURY
W. W. HORNER
H. L. WHITTEMORE
E. W. LANE
JOHN C. HOYT
INGE LYSE
ARTHUR CASAGRANDE
SHORTRIDGE HARDESTY
WILLIS R. GREGG
JOHN G. BRENNAN

Staff Reports from Flood Districts

UNIV OF MICHIGAN
GENERAL LIBRARY
ANN ARBOR MICH



Sad? Yes — but silly, too! There's little excuse for such fatalities in these days of medical science and education — and there's *no* excuse for premature and costly failures of pipe and sheet metal in these days of expert metallurgical knowledge. With Toncan Copper Molybdenum Iron available, the use of ordinary ferrous materials where corrosion is known to be a deciding factor is foolish economy.

REPUBLIC STEEL

TONCAN COPPER MOLYBDENUM IRON

HIGHEST RUST-RESISTANCE IN ITS PRICE CLASS

Toncan Iron is available through distributors in pipe and sheets and may be had in bars, plates, roofing, siding, boiler tubes, welding rod and other forms. For ordinary service these products may be had in steel or copper-bearing steel. Write for details.

Republic Steel Corporation

GENERAL OFFICES . . . CLEVELAND, OHIO

"When writing Republic Steel Corporation (or Steel and Tubes, Inc.) for further information, please address Department EN."

CONSTRUCTION
Surges Forward

THIS Annual Review Issue of *Engineering News-Record* presents an unusually interesting and stimulating picture of civil engineering and construction activity throughout the nation. To all those engineers, constructors, manufacturers, producers and distributors who are dependent on the industry, this picture carries a message of encouragement and opportunity.

For construction again is on the march. A strong upswing throughout 1936 now bids fair to be followed by sustained progress during 1937. From a low of $2.6 billions in 1932-33, construction volume has climbed through $3 billions in 1934, $3.7 billions in 1935 and now registers $5.6 billions for 1936. While general business and industry expanded during 1936 about 15 per cent over its 1935 volume, construction increased more than 50 per cent.

This follows the usual pattern of recovery: for a time construction lags behind general recovery and then surges strongly forward as it is called upon to make good the accumulated deficiency in capital facilities and to provide for the needs of a new expansion.

ALL this means that 1937 will be very distinctly a construction year and that for some time to come the construction market will be one of the most active. It is estimated that during 1937 the total volume of new construction may well reach $7 billions. Of this perhaps $1.25 billions would be for home building, leaving something more than $5.5 billions for new engineering construction. Allowing then a reasonable estimate for maintenance and operating expeditures, it looks as though engineering construction during 1937 should account for about $6.5 billions.

How much is $6.5 billions? How much of a market is here represented for services, materials and equipment? Just what does this industry spell today in terms of business opportunity?

The ordinary man does not think easily in terms of billions, so let us break this total down into more convenient fragments. Consider, for example, a week. Each week during 1937 it is estimated that engineering construction will consume something like $125,000,000 worth of services, materials and machinery. Still too large? Then assume a forty-hour week and take another crack at it. Now it breaks down to an hourly expenditure of more than $3,000,000. In other words, during every working hour of 1937 the engineers and constructors of the United States will spend somewhere near $3,000,000 for labor, materials, supplies, equipment and tools.

SO, as construction presses on in its forced march to overtake general recovery, it already has become an inviting market for every product that may be used in building, maintaining and operating the great variety of civil engineering works. Some idea of the diversity of those products may be gleaned from the Materials and Equipment Index of this issue. Yet, without doubt, many newly developed materials and appliances adaptable to this market have not yet found a place in this index.

In the cavalcade of American industry and business, construction once again is swinging into its accustomed place. And as it moves up it reopens those vast markets which in the past have created big volume and helped to build prosperous business.

For $3 millions per hour is pretty heavy "shopping" in any market at any time.

Willard Chevalier

ENGINEERING NEWS-RECORD Published every Thursday. Vol. 118, No. 5. Price 25c per copy. Subscription, domestic, Canada, Mexico, Central and South American countries, $5 per year. All other countries, $9 a year or 36 shillings. Entered as second-class matter October 29, 1936, at the Post Office at Albany, N. Y., under the act of March 3, 1879. Printed in U. S. A. Cable address "McGrawhill New York." Member A.B.P. Member A.B.C.

Copyright 1937 by McGRAW-HILL PUBLISHING COMPANY, INC.

Editorial and Executive Offices: 330 West 42d St., New York. Publication Office: 99-129 N. Broadway, Albany, N. Y. Branch Offices: 520 N. Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, London, W.C. 2, England; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga.

JAMES H. McGRAW, JR., Chairman — MALCOLM MUIR, President — JAMES H. McGRAW, Honorary Chairman
WILLARD CHEVALIER, Vice President — B. R. PUTNAM, Treasurer — D. C. McGRAW, Secretary

Table of Contents — See page 43

When the job is ready
. . so is INLAND PILING

WITHIN seven days of receipt of the order, Inland began shipping the largest tonnage of steel sheet piling ever used in a single project—the Grand Coulee Dam.

Hundreds of large and small jobs throughout the country point to the advantages of Inland piling. Inland sections drive freely and straight. The interlocks remain strong and tight under tension.

Write today for Inland's new sheet piling catalog, and plan to make use of Inland's practical experience with sheet piling installations on your next job.

Bridges and Crossings Made Safer with INLAND Traffic Plate

Rolled steel plates in 15 ft. lengths can be easily installed over wooden bridge floors and railway crossings. The four-direction non-skid projections of these Inland plates provide safe traction where it is most needed. The plates may be had in various thicknesses and sizes of projections. Punching and fastening are also supplied by Inland. Write for catalog.

INLAND Copper Alloy Gives 4 to 5 Years Longer Life

All Inland products—sheets, bars, shapes and plates—can be supplied in Inland copper alloy steel at slightly increased prices. Tests prove the superior resistance of Inland Copper Alloy over ordinary steel to atmospheric corrosion. Reports of these tests are available on request.

INLAND STEEL

INLAND Bars, Shapes and Plates Speed Construction Projects

The uniformity of Inland Steel, together with Inland's facilities for prompt delivery offer two important advantages to contractors and engineers. When you buy from Inland you are in direct contact with mills and metallurgists. You are assured of getting the right material, when you need

STRUCTURAL SHAPES • PILING • REINFORCING BARS • TRAFFIC PLATES • SHEETS • RAILS • TRACK ACCESSORIES

INLAND STEEL CO

General Offices: 38 South Dearborn Street, Chicago, Illinois

ENGINEERING NEWS-RECORD

McGraw-Hill Publishing Co., Inc.

Editorial and Executive Offices: 330 West 42d St., New York Publishing Office: 99-129 No. Broadway, Albany, N. Y.

Editorial Staff
V. T Boughton
W. G. Bowman

Chicago
W. W. DeBerard

F. E. Schmitt, *Editor* Willard Chevalier, *Vice-President*

Editorial Staff
C S. Hill
H. W. Richardson
E. J. Cleary

San Francisco
N. A. Bowers

FEBRUARY 4, 1937

Annual Review Number

Volume 118 Number 4 Copyright 1937

Flood News 151

An Editorial Review 157

Headlines of 1936 165

Construction Nears Six Billions 167

Advances in Selected Fields 173

- Civil Engineering Research ..... *I. Lyse*
- Hydraulic Progress ..... *E. W. Lane*
- Municipal Engineering ..... *W. W. Horner*
- Bridge Engineering ..... *S. Hardesty*
- Soil Mechanics ..... *A. Casagrande*
- Materials Improved ..... *H. L. Whittemore*

Status of Major Projects 182

Flood Control Begun .... *Brig. Gen. G. B. Pillsbury* 192

A Record of Droughts and Floods .... *J. C. Hoyt* 196

Forecasting Floodflows ..... *W. R. Gregg* 198

Crossing Elimination ..... *J. G. Brennan* 200

Current News 205

Business Side of Construction 208

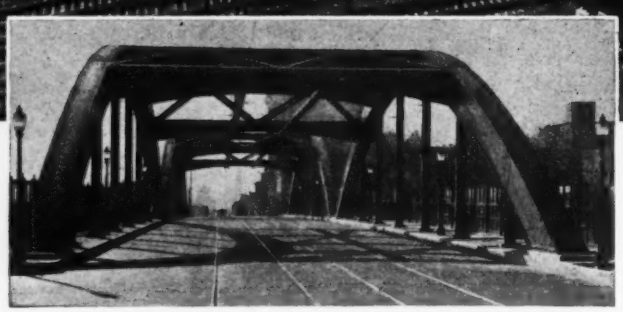
▼

Flood Plan Tested—The costly plans for control of floods in the lower Mississippi River valley, begun after the 1927 flood, are being tested by a flood greater than that of 1927. How well the strengthened levee system, cutoffs and floodways will function is of great interest to engineers concerned with river control. Editors of *Engineering News-Record* are on the ground to observe and report on the flood effects.

STURDY ARCHES OF STEEL *enhance* BALTIMORE BRIDGE

STRUCTURAL steel's adaptability to esthetic treatment is again shown by the Guilford Avenue Bridge in Baltimore. These new twin spans, of the 3-hinged tied-arch type, replace an old bridge consisting of two Warren-type trusses with cast iron top chords and eyebar bottom chords.

The complete finished structure was contracted for by American Bridge Company. This included fabrication and erection of all structural steelwork, construction of concrete substructure, piers, roadway and sidewalk decks and railing—as well as removal of the old structure. This was satisfactorily carried out under the hazards of uninterrupted train traffic on the electrified system below.



THESE ARCH SPANS *measure 174 feet between end bearings and carry a 40 foot roadway with two 5 foot, 8 inch sidewalks supported on cantilever brackets.*

THE ROADWAY *is asphalt planking laid on steel flooring of interlocking channels welded to the superstructure. Notice the sidewalk guard fence of ornamental steel railing with plate glass panels to protect pedestrians from the railroad electrification wires below.*

Built by Maryland State Road Commission for City of Baltimore under direct supervision of H. E. Tabler, Chairman, Nathan L. Smith, Chief Engineer, and Walter C. Hopkins, Bridge Engineer. Design developed by Engineering Department of the City of Baltimore, B. L. Crozier, Chief Engineer and H. F. Lucke, Jr., Associate Engineer.

AMERICAN BRIDGE COMPANY

General Offices: Frick Building, Pittsburgh, Pa.

Baltimore · Boston · Chicago · Cincinnati · Cleveland · Denver · Detroit
Duluth · Minneapolis · New York · Philadelphia · St. Louis

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

ENGINEERING NEWS-RECORD

February 4, 1937

Superflood Devastates Lower Ohio and Now Threatens Mississippi Levee System

Riverbank cities below Cincinnati largely or wholly submerged but Cairo still safe behind mud-box parapet . . . Mississippi levees to Helena prepare for critical attack . . . Floodways operate satisfactorially.

SURPASSING the worst fears all cities below Cincinnati were submerged by the great flood during the past week, with stages passing the highest previous record by 6 to 15 ft. Paducah, Shawneetown, Mound City and numerous other communities along the lower river were completely evacuated. Cairo still was safe on Feb. 3 behind a mud-box parapet along its Ohio River levee—largely by virtue of a flow of 400,000 sec.ft. through the Birds Point floodway.

Flood stages approaching the levee tops are expected along the Mississippi throughout the Memphis district, down to the mouth of the Arkansas, and armies of men are at work capping the levees at points where they have settled below grade. A breach on the east bank near Bessie Landing, just below Hickman, Ky., on Jan. 31, threatened to result in a permanent cutoff past New Madrid.

The virtually completed 1928 Mississippi flood-control project thus faces its first test, and this for extreme designed capacity, as the flood appears to be roughly equal to the "superflood" assumed in the design of the system. This is so in spite of the fact that the Missouri and the upper Mississippi are low.

The flood is of unusual flatness or length of crest, which gives time for flood flow to be added from the Arkansas in case of rains on that drainage area.

Conditions along the Ohio in Cairo and Memphis, and the work of dynamiting the Birds Point floodway, are described in articles on the following pages by W. W. DeBerard and H. W. Richardson of *Engineering News-Record*, who are in the flood zone to report its main events. A report from the Weather Bureau is also given, which shows that a rainstorm of unprecedented severity and length is responsible for the present flood; the storm

(*Continued on page* 205)

Mississippi Flood Fighting Begins

By H. W. Richardson
Associate Editor, Engineering News-Record

Memphis, Jan. 31

THE flood-protection works along the Mississippi River, built since the disastrous floods of 1927, are experiencing their first severe test as all-time record high water rolls out of the Ohio River Valley into the Mississippi. From Point Pleasant, West Virginia to Memphis, the present flood has passed all previous high marks by a large margin, and tonight the river below Memphis is slowly rising to new heights as far south as Vicksburg. What will happen downstream from Vicksburg is problematical, depending upon how the lower tributaries behave and how the main river crests flattens out as it travels down the valley.

Attack on the levees

Under the 1928 plan (the "Jadwin plan") for Mississippi flood control all main levees in the Memphis engineer district—which comprises the Mississippi River reach from the mouth of the Arkansas River to Cairo, the critical section at the moment—have been raised to take care of a 60-ft. flood stage at Cairo. Of 560 mi. of main levee involved in this district, 554 mi. are up to the new grade line. The planned capacity between levees is a "superflood" discharge of 2,250,000 sec.-ft. below Cairo. At six p.m. Sunday, Jan. 31, the Cairo gage stood at 59.31, with a crest height of 61 ft. expected early Wednesday. The crest discharge from the Ohio will be about 2,150,000 sec.-ft., with about 100,000 more from the upper Mississippi. Thus the present flood almost exactly reaches project capacity. Cairo is considered now safe, as all levees have been raised to 63 ft. by mudboxing.

Anticipating a superflood discharge, army engineers last Tuesday (Jan. 26) started raising all main levees in the entire Memphis district to carry a flow of 62 ft. on the Cairo gage, 2 ft. above project height. In the enlargement and raising of the levees since 1928 they had been built to excess height, as much as 4 ft. in places, to allow for settlement, but many places have settled to or slightly below the 62-ft. level while still others have subsided to or below project grade (60 ft.). Thus the job of raising to the new emergency level is one of attack on a multitude of levee sections, varying greatly in length and condition. This job is being done at incredible speed by 15,000 men—CCC, WPA and convict workers—under high ranking army engineers in four areas.

Sandbags and mudboxes

Civilian engineers attached to the district office who have fought Mississippi floods for years chart the possible trouble spots indicating low areas and those susceptible to sandboils, sloughing and wave washing. The raising is being done in general by sandbagging, though at some places mudboxes (double wooden bulkheads filled with mud) are used. The district has purchased over 7,000,000 bags and 2,000,000 board feet lumber for the fight.

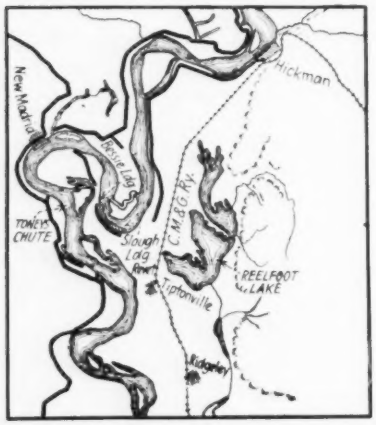
Where road conditions permit, supplies are kept and delivered on trucks. Where working conditions are more favorable from the riverside, floating plant is used

FLOOD STAGES ON OHIO AND MISSISSIPPI RIVERS

Location	Latest Stage	Actual or Predicted (P) Max.	Date	Previous Record	Date	Bank Full Stage
Cincinnati	71.5	80.	Jan. 26	71.1	1884	..
Louisville	52.6	57.1	Jan. 27	46.7	1884	..
Evansville	53.7	53.7	Jan. 31	48.4	1884	35
Paducah	60.7	60.8	Feb. 1	54.3	1913	39
Cairo	59.5	60.1	Feb. 3	56.9	1927	44
Memphis	47.85	50	Feb. 8	46.55	1913	34
Helena	56.5	.....	.....	56.75	1927	41
Vicksburg	45.2	50 (P)	.....	58.6	1927	42
Natchez	48.3	55 (P)	.....	57.45	1927	46
Baton Rouge	....	43 (P)	.....	47.8	1927	30
New Orleans	15.1	19 (P)	.....	21.27	1922	11

and the supplies are handled on barges. Reserve crews are kept with the supplies; portable radios provide communication. The work is almost entirely by hand, as there is no time to organize equipment. Engineers are confident that no breaks will occur in the main levees.

The emergency raising will be completed well ahead of the flood crest, which is expected to reach over 50 on the Memphis gage Feb. 7 or 8. The west or setback



NEAR BESSIE LANDING overtopping of secondary levees raises a threat of a river break over the seawall at Hickman into Reelfoot Lake.

levee of the New Madrid floodway is also being raised to 62 ft. level, about 15 of its 35 mi. requiring topping.

Desperate Fight at Bessie Landing

At present a desperate fight is being waged at four critical points. The worst is at Bessie Landing Dike and Slough Landing Neck Dike, extending for 10 miles along the Kentucky bank, from New Madrid upstream. These are old dikes built to keep the river in its course around the New Madrid bend, and have not been raised because of right-of-way controversy. It is important to hold this bend as the river threatens to cut across the neck and shorten its course by 20 miles. The neck is only 3 miles wide at low water, and the present differential in river elevations across it is 11 ft. A cutoff would develop high velocity, would disturb river conditions above, and would throw the flood directly against an important main levee on the Missouri side. It would also submerge the town of Tiptonville, Tenn.

Backwater has made the dikes slender islands, and for three days 1200 workmen have just barely kept ahead of the rising waters by a few inches. On Sunday, Jan. 31, the dikes were breached in two 100-ft. sections, but late reports indicate no serious cutting as yet. Frankly, the engineers expect to lose this fight.

Hickman wall threatened

Another tough spot is the Hickman, Ky., seawall. Bulkheading is progressing along the entire wall at frantic pace. Water is now at top of wall, and if the river gets through it will flood the town and flow through famous Reelfoot Lake, with possibility of changing its course permanently. The engineers are optimistic of their chances in holding this weak spot.

The other two danger points are at Mellwood and Ferguson, Ark., below Helena. At these locations the levees have subsided as much as 8 ft. below grades. One bad section is 2800 ft. long. These are being raised by mudboxes, and the work is well ahead of the rising waters—though the real flood is still far away upstream.

Boeuf may be flooded

Boeuf floodway is expected to go into operation soon, though the determined farmers of the basin are patrolling the fuse-plug levee and threaten resistance to opening. Bonnet Carré spillway needles have been dropped to permit diversion there when New Orleans is threatened. No doubt some water will spill into the Atchafalaya Basin.

The present flood is estimated to be about 25 per cent greater than previous record flows, which was that of the 1913 flood from Hickman to Memphis, 1927 elsewhere below Cairo. A 62-ft. stage at Cairo will exceed previous heights in the Memphis district as follows: At Cairo by 5.6 ft., at New Madrid by 10 ft., at Memphis by 8 ft., at Helena by 9 ft. If the Cairo crest does not exceed 61, as expected, these differentials will be reduced by from 3 in. to 1 ft.

Paducah Evacuation Typifies Conditions on Lower Ohio

By H. W. Richardson

U. S. Engr. Steamer "Penniman," Paducah, Ky., Jan. 29

EXCEPT for a fringe of residences in the outskirts, Paducah is completely inundated, and the Ohio River is sweeping through the streets at a terrific rate, hampering the continuous job of evacuation. The highest point in the business district is under 4 ft. of water, and the depth of water throughout the downtown section averages 6 ft.

Water supply out, power on

Yesterday the last of the city's water supply dribbled from empty reservoirs, and no more water will be available until 13 days after the river returns to a 51-ft. stage. This morning the river stands at 60.0 and is still rising. Previous high level was 54.3 in 1913; flood stage is 39. The local power plant is out; power is coming in from the outside, however, though service is often interrupted. While the power is a blessing to this stricken city, it results in some weird effects. Many stores, especially window displays, are ablaze with light, often under water, for storekeepers left the switches on when they fled the rising waters. An overhead traffic light at Sixth and Kentucky Sts. turns from red to green and back again with faithful regularity, though the boats pay no attention to it. Gas service has been out for several days.

RAISING Cairo floodwall with mud-boxes backed with sandbags

Whole city being evcauated

Under the personal direction of Gus Meyer of national headquarters, the Red Cross has assumed control of the local situation, working with the U.S. Army Engineers.

Evacuation is by coast guard boats, TVA boats and scores of small outboard motor boats sent in here from all over. The general plan is to collect refugees at a large barge anchored at the Cobb hotel and 17 other points, then transfer them to a main outpost station in Avondale, a suburb, where they are met by covered state highway trucks for transportation to Mayfield and other points to the South. The Red Cross is in charge of the outpost station, and is taking care of the refugees at the relief stations.

Access to headquarters at the Cobb hotel is by a few stairs from a barge to the top of marquee and through the second story window. County Judge Brady Stewart has been appointed chairman of the local Red Cross disaster committee and is handling the situation in fine shape.

U.S. engineers in charge

The U. S. Army Engineers under the direction of Col. R. C. Powell, Division Engr., Cincinnati, have taken over general control of rescue and evacuation work from Evansville to Cairo. All available floating plant that can be of any service at all has been pressed into use. A floating piledriver was used as a fire boat in extinguishing a carbide fire near the fleet Wednesday night.

Headquarters of the lower Ohio U. S. Engineer fleet have been established at Golconda, Ill. Col. Chas. P. Gross is in charge, with Major F. F. Frech directing

(*Continued on page* 206)

Conditions In Flood-Beleaguered Cairo

Levees barricaded against overtopping flood crest by mudbox bulkheads built to 3 ft. above wall—Emergency gate stuck—Many sandboils watched.

By W. W. DeBerard
Associate Editor, Engineering News-Record

Cairo, Jan. 29

CAIRO, a city of 15,000 at the southeastern tip of Illinois at the junction of the Ohio and Mississippi, has been fighting desperately to keep from being engulfed by the flood. At this writing (Friday, Jan. 29) it has succeeded at tremendous cost, and with splendid cooperation of all city, state and federal agencies. The Army engineers have superintended bulkheading the sea wall, where since Tuesday 2,500 laborers have worked in 12-hr. shifts; last night the job was completed for a length of 10,000 ft. The top of the levee is El. 60 and the bulkhead was built up to 63. Monday the gage stood at 58.65, the maximum in history. This reading persisted from 5 to 11 p.m. and then receded to 58.0 on Thursday, Jan. 28, when it started up and now (Jan. 29, 8 a.m.) stands at 58.4, with a maximum predicted by the veteran Cairo weather bureau forecaster, W. E. Barron, of 60 to 61.

Preparations for the defense of this city included many angles, not the least of which was evacuating 4,000 women and children and caring for the sick in crowded hospitals. This correspondent arrived Tuesday morning, Jan. 26, over the Illinois Central, which went out of commission shortly thereafter due to flooded tracks, leaving Highway 150 as the only land approach open.

Drainage facilities

Cairo's area within levees is 1400 acres, and its value (estimated in 1928) $36,000,000. This figure is given because the Missouri floodway is currently reported as having cost more than two-thirds as much. The city's ground elevation is 15 to 27 ft. below the 60-ft. levee top. An excellent drainage and sewer system is emptied by three pumping stations having a combined capacity at maximum load of about 125 m.g.d.

Normally the pump capacities are as follows: One at 16,000 g.p.m.; three at 14,000 and one each of 10,000 and 7,000 g.p.m., or a total of 75,000 g.p.m. All are motor-driven centrifugals of modern design. The largest is an Alberger, the others I. P. Morris, and the motors G.E. induction type. Power comes from the local electric generating station, which is today cribbing up its outdoor transformers, set 10 ft. above street level, so that in case of flooding current can be sent it from the out-of-town network. Condenser water is now fed by gravity with pumps, in a flooded well house on the water side of the levee, hung up in the rafters until the river recedes 11 ft., when they will be lowered into place.

The drainage system has so far been called on to utilize only one station, and the water level has been kept unusually low; few ponds are noted about the city. The capacity is estimated, roughly, as sufficient to care for a 4- to 5-in. rainfall in 24 hours, but would be of no particular value to cope with a major levee break. The drainage system can be cut into sections by gates in case of a sandboil breaking into it.

The levees on the Mississippi River (west) side of Cairo, greatly strengthened and left high for shrinkage, can probably take a stage of 62-63 easily and could be built up by bagged material from the levee back slope. The Ohio-side levees have been capped on their full 10,000-ft. length from the Illinois Central R.R. bridge approach to the junction with the Mississippi with an earth-filled cellular concrete wall construction back of the previously existing concrete seawall. This cellular structure is 10 ft. wide, with cross struts at 10-ft. intervals, and was built in sections 50 ft. long between expansion joints. The struts or abutments are supported on widened footings to limit the bearing pressure to 1 ton per sq.ft.

The old wall varies greatly in cross-section, from reinforced cantilever to gravity. The new cellular section was variously fitted to the old section, but in all cases a steel sheetpile cutoff varying from 12 to 50 ft. in length was driven to effect a long seepage path.

On top of this cellular wall the new mudbox bulkhead has been built during the past week.

Building the mudbox

Bulkheads on the Ohio River side were completed and filled 2 ft. on Jan. 26, and up another foot Jan. 27, using 500 CCC, 1200 WPA and 800 civilian laborers, directed by Army Engineers. They are fed by city commissary and housed in camps or vacant buildings. Material came in by rail, except for lumber, which was distributed by trucks. When completed this bulkhead had a general top elevation of 63 ft.—3 ft. above the top of the concrete seawall.

The construction consists of two rows of 5-ft. 2x4-in. stakes driven 2 ft. into the crown of the levee back of the concrete cap at 3½-ft. spacing. These rows are 24 to 28 in. apart and are sheeted on the inside by shiplap nailed to the stakes, alternate stakes being braced. The tops of a pair of stakes are tied together with wire. Filling is clay, hand-tamped into place with wooden tampers. The clay comes in bulk or in sacks, the latter being easier to handle suited to shipping in box cars. It is usually emptied from the sacks into the bulkhead, but the bags may be tamped down. Every possible variation of the above procedure is in evidence. Bags are used also to back up particular sections.

Driveways are cut through the concrete wall at the end of a number of streets about 5 ft. down from the 60 ft. top. These openings are closed by two rows of timber stop logs with clay packed between. While the stoplogs are calked with oakum and the bottom one is seated in a recessed sill in concrete, several were reinforced with sandbag backing.

Existence of two railroad tracks along this levee connected to the Illinois Central, Big Four and Missouri Pacific system greatly expedited the work. No shortage of material was apparent. One source of clay was just inside the north city limits, which is the Illinois Central bridge approach.

Flood gate closes street

On the Sycamore St. main entrance to the city under the high I.C. bridge approach is a 78-ton steel lift gate spanning the roadway between abutments. It is 22 ft. high, and the roadway is at elev. 42.1, so that when the gate is lowered it will hold a flood of 64.1 ft. elevation. To the north is the Cairo Levee District, which has earth levees all around to a height rather better than 60 ft., but at one place on the Mississippi side is a soft spot over a chronic sandboil area. The Army engineers had large crews at work blanketing it with brush and sandbags and putting in a sandbag toe in an effort to stop movement. No sheetpiling was driven around the District. Some sandboils have developed at other points in the district but were not considered serious. There is a cross levee on the south side of the Cache River from the Ohio to the Mississippi. Should any of these three levees give way, as has been the case in some previous floods, the Sycamore St. gate must be lowered to keep the water out of Cairo proper.

Gate repaired after sticking

In order to be sure the gate would operate an attempt was made Sunday, January 24, to start it. It was bitterly cold, and on one of the 2½-in shafts the winch, which has three reduction gears, was snapped. This happened at both ends. New shafts were turned out over night in a local shop and put in place. In the meanwhile four 80-ton jacks were installed on a cribbing of ties and the gate lifted from the short cross-beams spanning the gate slots and the gate lowered enough to indicate that everything was in working order. The concrete counterweights at either end are figured to balance the gate within 2 tons, but rust and friction probably greatly exceeded the pull on the winches. A recess in the concrete pavement makes a seal seat for the bottom of the gate, and in addition sandbags are piled high to seal and back up the gate.

Checking sandboils

In Cairo proper C. M. Roos, vice-president of the Cairo Water Co., has gained the reputation of sandboil expert because of what he did in the 1927 flood (crest 56.4). At that time a boil in the basement of a brewery caused a 200-cu.yd. cavity, but Roos handled it successfully. He is in charge of the sandboil work and visits each boil area daily. Much less trouble from boils has occurred due to the sheetpile cutoff in the Ohio side and great thickening of the levee on the Mississippi side. Also the flood has come up faster than usual, and time has not yet elapsed (Jan. 28) to raise the general groundwater level by the high river stage. Water analysis in the past indicated that the

groundwater does not come from the river (see *ENR* Feb. 23, 1928 and a report by C. E. Smith on the Cairo problem).

Definite chronic sandboil areas have been in existence for years. These are well known. I inspected them with Mr. Roos on Jan. 27 and found them typical of those in previous floods, and of those experienced in sandy terrain below Greenville in the 1927 flood back of the levees. They occur at the break between the ridges and valleys that are not yet filled in.

At Fortieth St., more than 2500 ft. from the Mississippi levee, is a chronic area which has broken out under and between two small cottages. The one between the houses has been surrounded with a ring of sand bags about 30 in. high and 6 ft. in diameter. The water was coming clear, and in fact the runoff lip had been lowered 6 in., since it was desired not to force more water into an adjoining boil under one of the houses which was discharging perhaps 1 sec. ft. and some fine silt. The house showed slight settlement. If the flow continues a sandbag ring can be thrown around the whole house or the house demolished, as it is old and not of great value. Another boil area half a block away has two active craters.

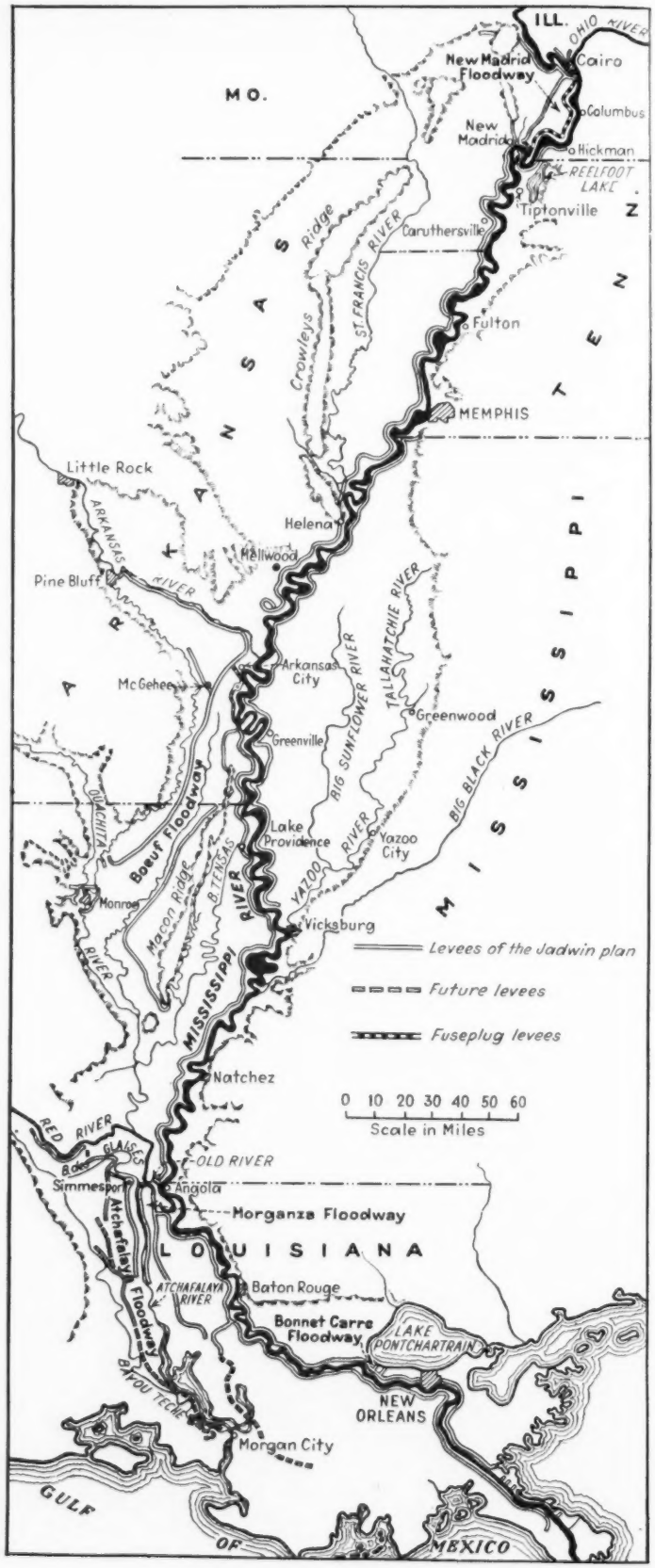
Dozen sandboils in small area

Perhaps the most interesting boil area is at 32nd and Poplar Sts., about 1000 ft. from the Mississippi levee. It is at the typical location of a break between a ridge and valley in back of a row of century-old brick and frame houses. The area covered is perhaps 200 ft. long near the breakoff of the ridge; it has some two dozen craters in all stages of development, from a crater which has built up a cone 2 ft. or so high and then practically stopped to a new and active boil 2 ft. across that is discharging silt and water over an outlet in a shallow rim a couple of inches high. The discharge from the whole area would not exceed 20 cu.yd. of material, but it has already caused the rear of one of the brick houses to sag a foot, and there were 6-in. cracks in the breakoff from the ridge, indicating that a cavity is being formed close to the surface. Nothing is being done with this area, as it is not considered serious nor as bad as in previous years. This low place will doubtless be filled at some later date 3 to 6 ft. deep, which will probably close the area entirely.

Water supply in good shape

Wells in Cairo that are 100 ft. deep, of which there are several dozen, flow during high water but none carry silt. The iron content of these wells is so high that the water has limited use (for condenser purposes only), and it soon clogs the pipes. Two artesian wells are 900 to 1000 ft. deep. One is the supply for the Halliday Hotel and is of good quality. One is near the Cairo Hotel. Measurements are being made of the height it would rise, with a view to piping it to a second or third floor of the hotel and there installing a small pump for emergency use should water come into Cairo.

The waterworks has functioned throughout in excellent style. Turbidities have been raised somewhat due to stirring up water in the sedimentation basin when water was taken for backflushing debris around the intake. A carload of coal is



MAJOR LEVEE SYSTEM ALONG MISSISSIPPI RIVER.

in the bins and two more on the track; a carload of alum is on hand and one more on track. Over 115 cylinders of chlorine, 100 lb. each, were on hand at the beginning of the flood. A few have been distributed to nearby towns. A heavy residual (0.5 to 1.0 p.p.m.) is maintained.

As an emergency precaution the 200,000-gal. elevated tank, 195 ft. high to water line, has been filled and shut off. Ordinarily it rides on the system only partly filled. A system of rationing with the supply on for 15 min. only at 4 to 6-hour intervals would keep consumers in second floors supplied for many days with culinary water.

The Cairo Water Co. has under construction new steel settling tanks, 350,000 gal., each of the spiral flow type. The tops will be at elev. 59. They are 65 ft. in diameter and 17 ft. high, resting on the ground at El. 42. New filters and a brick station will follow the tank construction. Confidence that Cairo will be kept dry was nowhere better exhibited than in continuation of the work of the welders erecting these tanks, only a few hundred feet from the hundreds of workers who are piling in clay to bring the bulkhead on the top of the levee to 63! Holes had been cut near the bottom in the side of the tanks to prevent their flotation—just in case.

Mute testimony of the other end of the Cairo water man's problem, low water, was a small pump house running on an inclined track down the levee. The pump house had been drawn to the crown of the levee, the two pumps removed and the electric wires disconnected. The adjoining power station once before borrowed this portable station to supply condenser water during repairs to their own station. They have asked again for the loan of it

(*Continued on page 205*)

Bonnet Carre Spillway Opened and "Fuseplugs" Ready

By Paul Wooton

ENR Washington Correspondent

First use of the Bonnet Carre spillway, thirty miles above New Orleans, was made Jan. 29. This was for the purpose of providing a cushion of water in the spillway in the event it should be desirable to use it for reducing the stage of the river as the crest of the present flood approaches. Another reason was to afford the personnel an opportunity to become familiar with the use of the equipment and with the handling of the needles.

Birds Point floodway a success

Members of the Corps of Engineers are convinced that the Birds Point-New Madrid floodway is the only thing that kept the water out of Cairo. Due to the fact that agreement had not been reached with all property owners in the floodway the 11-mile fuseplug sector had not been cut down the 3½ ft. to the contemplated 55-ft. grade recommended in the report. This made it necessary to blast openings in the fuseplug levee.

Some strengthening of the fuseplug levees at the head of the Boeuf and Atchafalaya basins will be undertaken by the Army Engineers. These sectors, however, will be left lower than the main levees so that overstopping if it occurs will take place at those points.

How Birds Point Fuseplug Levee Was Breached With Dynamite

Under the Jadwin Plan some 450,000 sec.-ft. was to flow into the Birds Point floodway over a fuseplug section of levee, where the levee top was to be cut down to the equivalent of El. 55 on the Cairo gage. But as not quite all of the flowage-rights cases had been settled the fuseplug had not been cut down from El. 57 to 58, its former crest height. Orders to evacuate the 3,000 residents in the 130,000 acre floodway had not been complied with, and some resistance to cutting the levee was offered until the Missouri National Guard was brought into action to protect the workmen who were sent to dynamite the levee after ineffectual efforts to cut it with shovels. Reports continued to come into Cairo that crevasses had taken place above and below Wolf Island, or the old 1927 Dorena Crevasse site. At this writing, Jan. 28, it is believed these refer to gaps in the New Madrid fuseplug never closed after the 1927 flood.

Two tons of dynamite

Dynamiting was ordered Sunday night Jan. 24, and an expert in earth dynamiting, P. H. Williams, representing the Austin Powder Co., Memphis was routed out of bed and dispatched to the upper end of the fuseplug at Birds Point. Arriving with 4,000 lb. of dynamite at the Missouri end of the bridge over the Mississippi, he with Major Burdick and crew proceeded along the slippery sleet-covered levee top (so-called rounded bicycle top) 1½ miles, the laborers each carrying a 50-lb. box of powder.

The first attempt was with three holes across the levee section, which blew out a ditch 25 ft. wide and 15 ft. deep. Later the plan was modified, different for sand and for buckshot clay. Two rows of holes were sunk 15 ft. apart in groups of 4, or 8 holes 10 ft. apart along the levee. Thus a 40- to 80-ft. length of levee was covered. Only one 80-ft. group was shot. The 40-ft. sections blew a hole 65 to 70 ft. long.

Dynamiting procedure

Holes were put down 8 ft. with 2-in. augers in clay and 6-in. post hole diggers in sandy material. In clay two sticks ½ lb. each were dropped to the bottom and exploded as "springers" to form a cavity at the bottom with smooth bore to the surface, into which 150 lb. of explosive was tamped and all 8 or 16 charges set off at once by wire and battery box. In sandy material the springers loosened up the saturated, mucky material, which was dug out by shovels to a depth of 5 ft., after which the three 50-lb. boxes of dynamite were pushed down as deep under the surface of muck and water as the men could tramp them. Nitroglycerine dynamite of 50 and 60 per cent strength was used.

Mr. Williams had lead lines 250 ft. long, but he kept the crew at least twice as far away. Though mud fell around him in quantity, he has become an adept dodger under such circumstances.

The first day (Monday, Jan. 25) four 65-ft. sections were cut. On Tuesday 17,500 lb. of dynamite was made available from Memphis by truck and a small amount from Cairo, to where the men had returned Monday night, and at a point 5 miles below the bridge two crews opened 765 ft. of levee, making a total of 1,025 ft. for the two days' operations. By Wednesday morning the break was estimated to be 3,000 ft. wide and water had risen in the floodway up to the top of the banquette, 8 or 10 ft. high.

DYNAMITING the fuseplug levee at the head of the Birds Point-New Madrid Floodway. Below, P. H. Williams, explosives expert, placing the dynamite; at right and below, the shot and the first water through the crevasse.

Memphis Commercial Appeal Photos

Twenty-Day Storm Caused Floods

Washington, Jan. 30, 1937

Indications today are that the Ohio River's tremendous discharge will be carried to the Gulf of Mexico without undue damage to either the Mississippi levee system or to the adjoining country. The only upsetting factor would be a severe storm along the headwaters of the lower Mississippi tributaries, adding new water in large quantities to the Ohio crest. Such a contingency is considered unlikely. Record-breaking gage heights are forecast only as far south as Helena.

Along the Ohio the flood was unprecedented in volume and in distribution. Throughout the middle and lower sections, from Point Pleasant (below Wheeling) to Cairo, all previous records were broken. At Cincinnati and Louisville, the two largest cities affected, the previous maximum flood heights (1884) were exceeded by 9 ft. and 10.4 ft., respectively.

Flood stage set in December

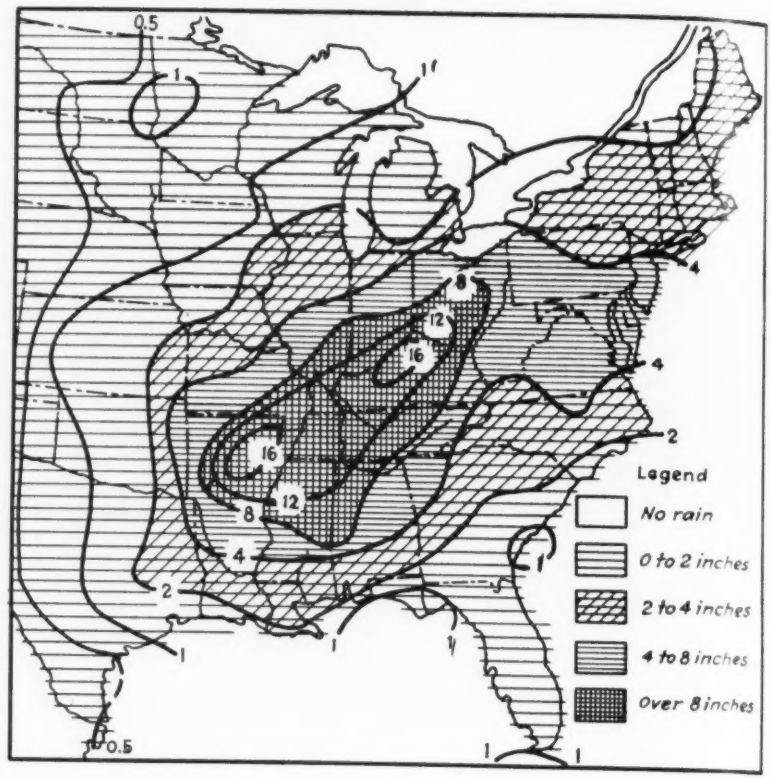
According to the U. S. Weather Bureau the stage for a phenomenal flood was set late in 1936. Abundant precipitation was general east of the Great Plains; by January the ground was well saturated and the Ohio and its tributaries were well above normal. Temperatures were high, and the precipitation was in the form of rain rather than snow. Early in January a high-pressure area centering near Bermuda balanced a second high-pressure area just west of the upper Mississippi basin, and this condition remained with little variation during a large part of the month. Between the two highs was a low-pressure trough extending from eastern Texas to western Pennsylvania, through which was sucked moisture-laden air from the Gulf of Mexico. The contact zone where this warm, moist air met the colder high-pressure areas experienced extremely high precipitation that continued over an unusually long period. From the Mississippi eastward, rainfall was unusually heavy; in parts of the Ohio and eastern Mississippi basins it was unprecedented. For the three weeks ending Jan. 26 the totals ranged up to over 16 in. The condition is shown graphically by the 20-day cumulative rainfall map herewith, reproduced from the Weather Bureau's "Weekly Bulletin."

Comparison with other storms

To compare with previous big flood storms: (1) The great flood of 1913, which led to the formation of the Miami Conservancy District in Ohio, resulted from a five-day rain totaling 10 in. over an area of approximately 10,000 sq.mi., and 7 in. over 100,000 sq.mi. (2) In March, 1936, the Connecticut River Valley over a 10,000-sq.mi. area had an average precipitation (with allowance for melting snow) of about 13 in., exceeding Miami's "greatest possible flood" and approaching its overload capacity. (3) In January, 1937, preliminary figures indicate a precipitation of 16 in. or more over two areas of 10,000 sq. mi. each, and of 12 in. or more over an area of approximately 100,000 sq.mi.

In designing the Birds Point floodway the Corps of Engineers calculated on a maximum flow in the Mississippi below Cairo of 2,400,000 sec.-ft. in their assumed "superflood." While no final discharge figure for the present flood in this region is yet available, preliminary estimates indicate that the expected volume will be approached by the Ohio alone—fortunately at a time when both the upper Mississippi and the Missouri are below normal. Were they also high, the Mississippi would go beyond the "superflood" volume.

The uncompleted program of the Tennessee Valley Authority helped materially to cut down the flood. Lying in the heart of the high-precipitation zone, the water retained by Norris, Wheeler and Wilson dams is believed to have reduced the crest at Paducah by about 1 ft.



THE RAINFALL between Jan. 6 and Jan. 26 reached a total of more than 8 in. over a large part of the Ohio River valley and attained a maximum of 16 in.

Tennessee Flow Cut by Norris Dam

Knoxville, Tenn., Jan. 29

Norris Dam, closed and discharging no water since Dec. 22, now is carrying water only 4.8 ft. below the top of the crest gates. The flood-reducing effect at Paducah has been estimated, unofficially, as more than 30,000 sec.-ft., and perhaps 1 ft. in crest height of the Ohio. In addition Norris probably saved extensive damage at Chattanooga.

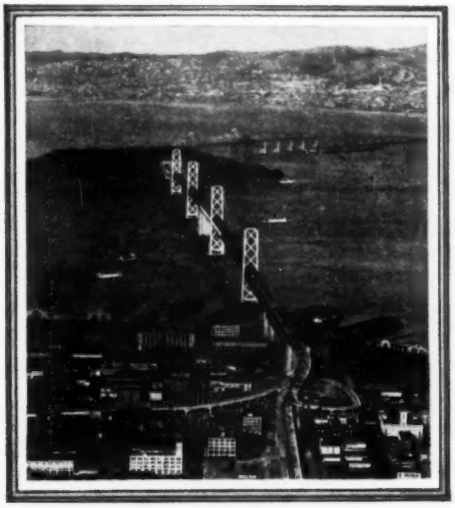
It is now going to be necessary to empty Norris as fast as possible to regain flood-storage capacity, ready for any floods that may come this spring.

FLOOD DISCHARGES AT GAGING STATIONS OF U. S. GEOLOGICAL SURVEY

Crest Stages, Except Those Marked With Asterisk

Location	Maximum, 1937 Date	Stage	Sec.Ft.	Previously Recorded Date	Stage	Maximum Sec.Ft.
Miss. R., Memphis, Tenn.*	1/29	44.6	1,800,000	April 9, 1913	45.5	
Ohio R., Paducah, Ky.	2/ 1	60.7	1,980,000†	April 7, 1913	54.3	
Ohio R., Cincinnati, O.[1]	1/26	80.0	950,000	Feb. 14, 1884	71.1	
Ohio R., Louisville, Ky.	1/27	57.1	1,100,000	Feb. 18, 1884	46.7	
Muskingum R., McConnellsville, O.	1/26	21.0	130,000	Mar. 27, 1913	33.5	270,000
Hocking R., Athens, O.	1/25	22.4	27,900	Jan. 1907	26.7	
Scioto R., Chillicothe, O.	1/25	27.8	111,000	Mar. 26, 1913	39.8	250,000
Licking R., Catauba, Ky.	1/25	.....	80,000	.....	.....	.....
Miami R., Hamilton, O.	1/22	76.4	76,000	.....	.....	.....
Miami R., Venice, O.[2]	.....	.....	.....	Mar. 26, 1913	.....	370,000
Kentucky R., Frankfort, Ky.	1/25	46.2†	93,000	Feb. 1878	44.0	.....
Green R., Livermore, Ky.	1/29	50 [4]	.....	.....	.....	.....
Wabash R., Mt. Carmel, Ill.	1/22	25.0	286,000	Mar. 30, 1913	27.65	428,000
White R., Hazelton, Ind.	1/22	31.6	180,000	.....	.....	.....
Cumberland R., Clarksville, Tenn.	1/25	65.7	263,000	Jan. 1882	60.6	220,000
Tennessee R., Buchanan, Tenn.	1/25	51.4	370,000	.....	44.5	332,000
Obion R., Obion, Tenn.	1/25	25.25	66,500	Jan. 11, 1930	21.9	47,000
Forked Deer R., Chestnut Bluff, Tenn.	1/25	21.33	27,400	Jan. 22, 1935	22.3	33,300
Hatchie R., Stanton, Tenn.	1/23	19.29	44,500	Jan. 22, 1935	20.35	50,000
Wolf R., Rossville, Tenn.	1/22	10.68	11,600	Jan. 20, 1935	13.75	31,000
St. Francis R., Marked Tree, Ark.*	1/29	.....	57,000[3]	.....	.....	.....
White R., DeValls Bluff, Ark.*	1/26	29.6	150,000	April 23, 1927	34.6	.....

* Not crest stages. † Approximate crest: including 200,000 sec.ft., estimated overflow.
[1] Weather Bureau Station. [2] Venice gaging station located 10 miles below Hamilton.
[3] Includes discharge through floodway. [4] Backwater.



Civil Engineering In 1936 —*An Editorial Survey*

Forward in Construction

Powerful and sustained advance in construction activity characterized the country's industrial and business progress during 1936. In sharp contrast to the two previous years, when construction lagged badly, the past year saw it leap ahead from 3.7 billions in 1935 to 5.6 billions in 1936, the latter figure nearly two-thirds of the pre-depression normal. This gain of 52 per cent, more than three times as large as the gain in national production signifies the revival of the last and largest unit of the capital-goods industries, and thus appears to open the final phase of recovery. Constructions increase alone took nearly two million men off the unemployed list.

The nature of the increase is no less remarkable than its amount. Private construction gained most of all; as for public works, large federal undertakings decreased, and works construction by local authorities made a counterbalancing increase. Major items of the year's record are active industrial plant construction, beginnings of resumed utility expansion, and further growth of housebuilding from the abnormally low level of '33–'34. The activity in private construction testifies to effective restoration of enterprise and of faith in the future, while the public-works readjustment indicates that we are returning to normal relations in government and finance.

Industry in Black Ink

General business conditions provided a favorable background for construction forecasts. Industry and business as a whole carried forward their 1935 advance consistently, undeterred by such front-page events as flood, drought and presidential election. According to official estimates the national income grew from 53 to 60 billions. Operating at a loss came to be the exception rather than the rule; increased volume brought large groups of industry to the point of realizing substantial profits. In fact, demand was sufficient to require some industries to set delivery dates months ahead, and shortages of skilled labor were reported from many points. Rising wage and cost levels tended to accentuate the condition by stimulating forward orders.

On the whole the momentum of industry, the pressure of depression shortages, low money rates and ample capital supply, justify the conclusion that investment needs will increase during the coming year to the point of carrying construction up to a $7,000,000,000 total. Growth in factory and utility construction should contribute largely to this figure, and increased housebuilding—a field in which 1937 is likely to double the 1936 performance—should also add a half-billion dollars.

Power at New High

Incidental to the general advance, yet of basic significance as a milestone of progress, is the return of electric power consumption to pre-depression levels and beyond. New highs were reached during 1936 in both total and per capita demand. Consumption rose by some 12,000 million kwh to a total of 89,775 million. The movement has broad importance as a reputation of prior beliefs that electric consumption had reached its ceiling. If there was a ceiling it has been raised, and this means that increased utility development is ahead, even without regard to such coming developments as highway lighting. The progressive replacement of muscle power by

machine power, besides increasing human efficiency, will also call for more engineering and construction activity.

Flood and Drought

In contrast to the favorable natural conditions of 1935, major catastrophies of flood and drought punctuated the 1936 record. The factual story of weather and water in relation to engineering is told on a later page by John C. Hoyt. March brought floods far beyond precedent throughout an entire sector of the country. Their dimensions were so unforeseen that even quite recent control studies of the Connecticut River had to be scrapped. An important teaching of the flood was the lesson that community service equipment, such as power plants and the key elements of water supplies, must be so placed or protected that floods cannot stop their functioning.

Later in the year an intense drought seared the northern Great Plains area. Though less severe than that of '34 it was more disastrous because it came after a series of bad years. It proved beyond doubt that there is a real Great Plains problem.

Regional Problems

Late in the year government officials reported that ten to twenty thousand families had moved from the northern Great Plains as a result of their drought experience; predictions are that a much larger movement will follow. No systematic provision for the population shift has been attempted by state or federal authorities. The situation presents one of the regional problems that have been emerging within recent years and more distinctly during 1936. Official recognition was given to river-region problems by the comprehensive study of some 120 drainage basins carried out during the year by the National Resources Committee.

Public Affairs

Flood Control Act

The March flood disaster, which extended from Pittsburgh to Maine, shocked the public consciousness quite like the 1927 Mississippi flood and like it led to a profound change in government policy. Congress adopted flood control as a federal responsibility, subject only to payment of land and damages by local interests. No recognition of the principle of payment for benefits is contained in the act. The major studies authorized were those for the Pittsburgh-New England region.

Labor Controversies

Passage of the National Labor Relations Act (Wagner Act) wrought another major change in government policy by introducing an obscure sort of federal supervision of the relations between employers and workers. Its one-sided terms—the act restrains employers but not workers—its limitation to interstate operations, and questionable procedure in its administration, set the stage for many labor controversies. The close of the year brought no court adjudication of federal authority over labor relations, and no clarification of strike and labor dispute matters.

Labor controversies centered on unionization, including worker control of employment, and only to a minor extent on wages. The establishment of a vertical union system through a split in organized labor ranks was accomplished by a Committee on Industrial Organization, which separated from the American Federation of Labor. By the close of the year the movement had reached the point of "sitdown strikes" on the French model and refusal of state authorities to act to clear factories of the trespassers.

Big Federal Projects

No large federal works were started during the year. Boulder Dam is completed and in operation, the All-American Canal works, Parker Dam and the Rio Grande improvements are well along, as are also Bonneville, Grand Coulee and Fort Peck. Most of the engineering on the federal projects has been carried to the point where only routine details remain. The action of the last Congress in disapproving continuation of work on the Florida Canal and the Passamaquoddy tide power plant indicates that except for flood control and reclamation there is likely to be little more in the way of big government works for some time to come.

The Public-Works Movement

PWA activities reached their virtual end during the year. Nominally the last project approvals and grants were made shortly after the beginning of the year, but actually there were some subsequent allocations from various fund balances. The PWA public-works campaign to promote recovery thus in effect reached an end. However, the PWA's report of results deserves an important place in economic records because of the proof of the large contribution made by PWA to recovery. Analyses of indirect employment effects made by the U. S. Labor Department showed that for every man-year of direct employment in PWA construction 2½ additional man-years were created in the supply of materials, in transportation and related operations.

Work relief, instituted in 1935, continued throughout the year with about 3½ million persons employed. The initial principles were not well maintained however; the operations of the Works Progress Administration entered extensively into the field of regular city and state activities and into that of private contract employment. The subsistence wage principle also was not consistently adhered to. Unionization and strikes further diversified the WPA picture. Little progress was made in returning the employment problem to local authorities, and WPA workers largely came to regard their work as regular and permanent employment.

Cities Demand Help

Part of the relief problem lies in the unwillingness of cities to reassume their relief load and their demand to have the federal work-relief system continue. Related demands were made during the year by a moyors' conference, which asked that provision for federal financing of cities be continued—in the face of unprecedentedly low money rates on city securities. As noted elsewhere, city revenues are rapidly returning to normally good condition, though against this there is constant agitation by real estate interests to reduce property taxes. Increasing demand by cities that gasoline tax moneys

be turned over to them also reflects the desire to find other sources of revenue.

A Public Works Department Promise that the long-hoped-for federal public-works department may soon be realized was contained in reorganization proposals developed for the President by a special committee late in the year and soon afterward submitted by him to Congress. A welfare department and a works department are the chief items of the proposed reorganization.

Transportation

Railroad Improvement Railroad income increased as a result of improved business, and the better financial condition of the roads during the latter part of the year is being reflected in increased expenditures for maintenance and new equipment. Maintenance-of-way expenditures are rising—to $456,000,000 for 1936 as compared with $800,000,000 annually in pre-depression days and a low of $322,000,000 in 1933. The indications are that 1937 expenditures will go well above 1936.

New construction, other than grade-crossing elimination, was almost negligible in terms of both dollars and mileage. Less than 100 mi. was built, while over 1,500 mi. was abandoned during the year, somewhat less than the record for the three years previous. A full statement of the grade-crossing elimination situation by J. G. Brennan is published on a later page.

A few railroads spent some money on line and grade improvement to facilitate the operation of high-speed trains; a large amount of such money can be expected to be spent in the near future as the net income of the railroad companies rises.

Trucks and Safety The Motor Carrier Act, passed in 1935, began to be put into effect in a limited way during 1936. It is expected to do much to put buses and trucks on a more equitable competitive basis with the railroads and to help define the fields in which each form of transportation is most efficient and economical. The effect of the act on highway safety is expected to be felt soon, as the Interstate Commerce Commission recently promulgated safety rules relating to driving and safety appliances which are applicable to motor vehicles engaged in interstate commerce as common carriers.

Florida to St. Lawrence No new waterways of importance were opened during the year, but good progress was made on the waterway improvements now in hand, notably the work on the upper Mississippi and the Tennessee. In coast waters, deepening and enlargement of the Cape Cod and of the Chesapeake & Delaware Canal went forward actively.

Work on the Trans-Florida canal came to a standstill in the spring after Congress declined to provide money to continue construction. A new report recommending that the canal be built, prepared by a special board of army officers, was submitted to the Board of Engineers for Rivers and Harbors during the latter part of the year, but no final action was announced.

Nothing of any consequence was done to advance the start of work on the projected development of the international section of the St. Lawrence River for navigation and power. Opposition to the project is strong in Canada.

Highway Advance

Better Road Planning Outstanding achievements in highways must be marked up for 1936. The express road and the freeway have become definite parts of highway thinking—perhaps soon also of planning. Reconstruction of existing first-class roads has come to be accepted as a necessary future activity. The secondary road moved more definitely into the foreground of the highway picture. Grade-crossing elimination has made large advances. The technique of design and construction for safety has progressed, and highway organizations now include traffic engineering, roadside development and long-time planning as continuing elements of administration. In the last named field, long-time planning of road systems, an inspiring part is being played by the road inventories and financial and traffic surveys inaugurated by the Bureau of Public Roads and actively undertaken in 1936 by some 40 state highway departments.

Grade Crossings Aside from large bridge and elevated city highway projects, the major development in the road field was the elimination and protection of grade crossings. Under the works legislation of 1935 the curve of progress turned sharply upward, and the figures at the end of 1936 showed 4,291 crossings improved—3,125 eliminated and 1,166 protected by flash signals. These figures do not include crossings eliminated by highway relocation.

New Road Work In respect to the actual road construction of the past year and the expected construction of the year ahead it is difficult to give truly representative figures because both appropriation of funds and actual construction are overlapping operations. If we take an average of the past three years as a basis, the Bureau of Public Roads has controlled an annual state and federal expenditure of $375,000,000 for construction. The federal-aid funds for the ensuing year, $200,000,000, call for a matching state fund of $150,000,000, which makes a total of $350,000,000; this money together with the balance of previous funds available for new projects (if the states provide the required matching moneys) amounts to $800,000,000.

Research and Technique Highway research has held closely to the conventional problems of concrete and bituminous mix design. In the field of brick paving, tests of de-aired brick and study of joint fillers were the chief research activities. The major development of the year was the forward work of soil mechanics laboratories and the advance of practical soil study,

particularly in respect to stabilization. Experimentation on large scale is being carried on with calcium chloride, sodium chloride, cement, asphalt, lignin and tar as stabilizing agents.

In respect to road technique, either in design or construction, there is less to be said. Pavement design and types show few radical changes, but skill in pavement construction increased perceptibly. The most important advance of highway engineering was in foundation stabilization.

Express and Arterial Roads

The year has given the world a series of highway projects on a magnificant scale. Abroad the Germans have set an example of nationwide planning of express highways. Great Britain has taken steps to nationalize its intercity trunk roads. France is engaged in revamping to superhighway proportions the motor road system around Paris. Hungary has completed its border-to-border superhighway. In the western hemisphere Mexico has completed its Laredo-Mexico City highway and is pushing it south to Yucatan. In Argentina, Buenos Aires and Rosario (235 mi. apart) have been connected by modern pavement. These roads in Mexico and Argentina, in addition to their national importance, are two vital links in the actively developing international highway connecting the countries of the two Americas.

Getting back to the United States, the outstanding road projects of the year are bridge links. The Triborough bridge and its connecting road system in New York City and, across the continent, the Oakland-San Francisco Bay bridge and its approach highway system, rank among the great road projects of all time. Depressed and elevated express roads cutting through city street systems loom fully as large as great bridge-road projects. Two notable examples are the St. Louis depressed road and the West-Side Elevated Highway and Henry Hudson parkway continuation north at New York City.

Water and Power

Flood Surveys and Work

Congress included in the new flood-control legislation already mentioned an authorization for the construction of 270 flood control projects—mostly hastily conceived and inadequately studied—but only appropriated enough money to permit the army engineers to proceed with the much needed surveys. Work on the so-called Jadwin plan for flood control on the lower Mississippi River, in so far as that plan is to be made effective, was nearly completed at the end of the year, and Congress, through the passage of the Overton Act, authorized the army engineers to proceed with the Markham plan for continuing the flood-control work in the lower river. The act authorized the expenditure of $252,000,000. The series of cutoffs between Arkansas City and Red River had been completed early in the year as part of the former plan, though not originally included. Also various sand-dike training walls have been built to stabilize the channel. Adding to the project so carried through, the Markham plan abandons the Boeuf floodway and substitutes a floodway through the Tensas valley, with entrance at Eudora, which has not yet been started. It also includes enlargement of the Atchafalaya floodway and gives it a second entrance.

An interesting element of the work on the Lower Mississippi is the virtual adoption of the asphaltmat revetment as standard in place of the more costly concrete mats.

Basin Flood Control

Good progress was made during the year on two other flood-control projects, designed to treat smaller river basins as a unit, the Muskingum Valley project in Ohio and the Winooski Valley project in Vermont. Ambitious programs for two river valleys in Texas, the Brazos and Colorado, were inaugurated during the year, the work nominally being done by river authorities set up by the state and supplied with emergency relief funds; actually the major part of the initial construction is being carried out either by the Bureau of Reclamation or by the Corps of Engineers. Scattered river conservation projects, not yet part of an adopted plan for a river system, include the Tygart and Bluestone reservoirs on tributaries of the Ohio, and Conchas dam on the South Canadian River in New Mexico.

Water Power Developments

Power generation was begun at Boulder dam in September, the ceremony of starting one of the small station units being made a feature of the World Power Conference in Washington; the first main unit started some weeks later. The large generators, of 82,500 kw. capacity, set a new record for electrical output, though in physical size they will be exceeded by the 48,000 kw. generators now being installed in Bonneville dam.

Power generation also was begun at Norris dam, first of the dams to be built by the Tennessee Valley Authority, and power soon will be generated at Wheeler dam, the second TVA dam and the first to be built by that body on the main river. Early in the year work was begun on Chickamauga dam, which with Pickwick and Guntersville makes four dams either completed or under construction by the TVA on the main river.

By the way, the contribution of Norris dam to flood control on the Tennessee River was recorded in an estimated reduction in the flood crest of March, 1936, at Chattanooga of 3 to 4 ft.—and of 2 ft. in the flood of two weeks ago.

Rapid headway was made at Bonneville dam on the Columbia River, a combined power and navigation project, but no progress was made toward adopting a definite program for the disposition of the power to be developed there. Grand Coulee still is only a dam-base project, though efforts to have Congress provide money to complete the dam are to be made this winter. Work on the Passamajuoddy tidal power scheme in Maine was greatly curtailed after Congress declined to provide additional funds.

New Interest in Polluted Rivers

Stream pollution abatement is closer of realization than ever before, as a result of widespread and live interest in the establishment of federal legislation. Several bills for controlling pollution were introduced in Congress and one of these (providing for U. S. Public Health Service supervision, grants-in-laid to municipalities and loans to industries for the construction of treatment facilities)

missed passage by only a narrow margin. Authority to negotiate interstate compacts for solving the pollution problem of the Ohio and Connecticut rivers was granted by the Citron Act. This resulted in the formation of the Ohio Valley Treaty Commission, a temporary organization of New York, Ohio, Kentucky, Indiana, and Illinois state representatives.

City Engineering

Municipal Finances City finances are in much better shape than in the past few years, as evidenced by the low interest rate that municipal bonds now command and the rapidity with which new issues are being absorbed. However, many places are using revenue bonds paid for by service charges, especially for new sewer construction. Tax collections have improved, but some of warrants based on delinquencies of past years are poor paper: Statutory property tax limitation laws generally failed of passage in the November election. Relief requirements recently loaded on the cities negative some of the brighter phases of city finance.

Increased Water Needs Increased water-supply problems claimed attention during the year as renewed droughts and increasing consumption revealed the inadequacy of existing facilities. In the Mid-West depletion of groundwater resources led to further development of impounded surface supplies. Industrial activity and air-conditioning installations are taxing water systems in a good many communities. To meet these increased needs, construction has been started on numerous projects, a typical example being the long-delayed Delaware River supply for New York City, which got under way late in the year. Los Angeles, Denver, Fort Smith, and Little Rock have gone to distant sources for their water to assure sufficient future supplies. Treatment methods are being perfected to meet consumer demands for better water quality. Iron and manganese removal and softening plants are being installed in greater numbers. Large cities for the first time are demanding soft water; it is expected that Los Angeles will treat Colorado River water before distributing it. Activated-carbon treatment is becoming almost universal for the elimination of tastes and odors.

Pipes and Valves Water system operation and distribution efficiencies have been bettered, principally by the application of automatic control devices and through the use of improved pumping equipment. Bituminous spun lining for large steel pipes is credited with increasing the carrying capacity to the equivalent of $C = 130$ and 140 in the Hazen-Williams formula. Cities are tending to limit cast-iron pipe to maximum sizes of 30 and 36 in. So great is the demand for automatic-closing valves on long lines under heavy pressures that one manufacturer has a year's orders ahead. Quite generally, distribution engineers are finding it advisable to install better valve controls, particularly on the outlets of large reservoirs. Finally, the tendency toward elevated storage continues.

Better Sanitation Facilities Sewerage developments were characterized by steady growth in public demand for better sanitary facilities. Sewer and treatment projects costing $120,000,000 were built last year, it is estimated—an all-time high, to be compared with an average annual expenditure of $78,000,000 during the last decade.

Progress in sewage treatment has been marked by consistent refinement and perfection of existing processes rather than by any spectacular or revolutionary innovation in methods. The significant trend in disposal plant design has been the utilization of combinations of biological, chemical, and mechanical processes, each placed in a role where it would be most effective in producing desired end results with greatest economy. A decided trend toward the use of sludge gas for power production developed, and simultaneously there was increasing use of incineration for sludge disposal. Mechanical filtration also gained favor as an adjunct to both primary and secondary clarification units. The trickling filter was elevated to a new position of importance as the result of investigation which revealed that under certain conditions of operation it would handle loads more than eight times greater than thought possible. Research indicates that we have only just begun to utilize the potentialities of the various processes.

City Waste and Refuse Refuse disposal is receiving lively attention in municipal improvement programming. The trend is all toward incineration, consistent improvement in the design and operation of incinerators having largely removed former objections to it. There are now about 700 plants in this country and Canada. The possibilities of power generation from burning wastes have never been fully explored; experience at the Providence installation, placed in operation late last year, will bear watching. New York City has under construction a 750-ton incinerator where electricity will be generated. At the Atlanta incinerator (where the sale of generated steam reduces operating costs by 40 per cent) investigations are under way in connection with grinding refuse to a uniform size and blowing it into the furnaces.

Against this, however, it is to be noted that St. Louis has built a second garbage-grinding plant for disposal into sewers. The sanitary-fill method of disposal was approved by authorities in San Francisco after several years' experimentation, and a ten-year franchise was granted to continue this method.

Streets and Traffic Activity in street paving during the past year was noteworthy, perhaps because paving is easily adapted to work-relief operations. Resurfacing of pavements and restoration of curbs and gutters were the principal phases of activity. There was much interest in the development of non-skid carpet surfaces that could be laid over existing bases. Marked advance was made in knowledge of bituminous mixes. Concrete pavement technique, already on a high plane of efficiency, showed little change. Brick paving practice was improved through active experimental work on cushions and joint fillers.

Traffic control continues to trouble municipalities in increasing degree. Milwaukee's leadership in "channelization" to eliminate wide spaces at intersections is being

emulated by other cities. Progressive systems of stop-and-go signals are on the increase, as are automatic vehicle-control devices. Parking provisions have been augmented in a number of places by demolition of obsolete buildings; metered parking installations have spread rapidly. In some quarters it is felt that there will be a great expansion of elevated or depressed thoroughfares; their high cost per mile, is the present deterrent.

The Municipal Outlook The municipal outlook for 1937 is favorable. Acceleration of the revival in municipal works activity that began in 1936 is to be expected as certain. Now that finances are better, attention is bound to be directed toward reducing the huge deficit of unfulfilled construction and maintenance needs that piled up in the depression. How many new projects will be undertaken depends, however, to some degree on federal largess, actual or potential. If the cities definitely knew that grants were not obtainable, many sizable projects would go ahead, as, for instance, the water filtration program for Chicago. A desirable separation of relief from public works is on the horizon.

Among wholly new activities in the municipal field, public housing stands foremost. This new department of governmental interest presents many unsolved problems, however, whose solution will tax the ingenuity and thinking of public officials. Connected with housing, often erroneously so, is slum reclamation and the rehabilitation of blighted areas.

Structural Developments

The Year In Structures Spectacular developments in the structural art such as the announcement of a Golden Gate Bridge, a Boulder Dam or a Rockefeller Center were lacking for the first time in several years. The opening of the Bay Bridge at San Francisco and the Triborough Bridge at New York were events of note, but the technical advance that they represent, with the possible exception of unusual speed of erection, belongs to an earlier period. More money was spent for bridges in 1936 than in any previous year, a record made possible by grade-crossing expenditures. This latter activity also fostered rigid-frame studies—on concrete at the University of Illinois and on steel at the Bureau of Standards. The steel rigid-frame tests demonstrated that the stress path at the knee does not follow the outer flange but cuts across the web; outer corner reinforcement is thus unnecessary. Span lengths for concrete rigid frames were progressively lengthened during the year, a 100-ft. barrel frame being built at Canton, Mo., a 109-ft. rib frame with counterweighted side spans in Nebraska, a 146-ft. rib span in Wisconsin and a 175-ft. rib frame in Seattle, longest by far of any in this country. In Riverside Park, New York, the New York Central Railroad is being put in a subway framed with steel rigid frames of silicon steel.

New Dimensions Several more continuous-truss bridges emphasized the growing acceptance of this type of design. The most notable structure was erected across the Missouri River near St. Louis and consisted of two 1,025-ft. continuous trusses each of two spans. At Hannibal, Mo., a 1,125-ft. two-span continuous truss was opened across the Mississippi River. The Homestead Bridge at Pittsburgh, with pinned quadrilateral panels over the piers, is the first such continuous bridge to be built. In Syracuse nickel-steel girders weighing up to 147 tons each were used in the new elevated line of the New York Central R. R. Near Cleveland the Lorain Ave. viaduct, a series of four deck arches, introduced smooth-surface members, achieved by welded seams and by countersinking all minor rivet heads.

During the year a movement was inaugurated by the American Society of Civil Engineers to secure War Department cooperation in developing a uniform policy with respect to bridge clearances. The welding specifications of the American Welding Society proposed design methods to take account of fluctuating stresses. An epidemic of collapses of old bridge spans resulting from trucks colliding with them emphasized strongly the danger of narrow bridges. The use of a safety net below the workers on the Golden Gate Bridge saved eleven lives in addition to being a definite factor in speeding up the work of steel erection.

Light Bridge Floors In the field of movable bridges, unusual increase in area of deck was recorded: Outer Drive bascule, Chicago, 17,500 sq.ft. per leaf; Harlem River lift span of Triborough Bridge, New York, 23,250 sq.ft.; and Marine Parkway lift span, New York, 29,700 sq.ft. Synchronous drive from motors in the towers characterizes the two lift bridges; also light-weight decks—welded steel plates and asphalt plank on the Harlem River bridge and open steel mesh on the Marine Parkway Bridge. An old bascule in Bridgeport, Conn. was refloored with aluminum channels and asphalt plank.

Developments In Dams Two important dam strengthening operations were carried out. On the Lake Pleasant multiple arch dam in Arizona the badly cracked hollow buttresses were strengthened by building in several horizontal diaphragms of heavy T-rails prestressed by jacks, to carry the tensile stresses from the upstream to the downstream face. On San Diego's Hodges Dam, also of multiple-arch type, repair work was directed to bracing the cracked buttresses for more stability against earthquakes. Increasing the height of O'Shaughnessy Dam on San Francisco's Hetch Hetchy system involves the bonding of the new concrete to the old on the downstream face.

Several rockfill dams were built with welded steel plates for upstream facing. Earth dams built in the Santa Clara Valley in California were covered with a thick gravel layer in turn surfaced with rock fill as an earthquake measure.

In the Concrete Field Concrete and steel as engineering materials were subjected to increased scrutiny in the laboratory and in the field. Durability is becoming the most desired attribute of concrete but, lacking sufficient knowledge of the factors which assure it, the industry is attacking the problem through the medium of higher strengths; the new ACI code requires all exposed concrete except in mild climates to

have a 28-day strength of 3,000 per sq.in. Prestressing of bars to eliminate tension cracking is being used for large tanks and is being studied for other applications in several laboratories. Refinement of concrete-making to achieve laboratory uniformity on the job continues. A method of extracting excess water from slab and column concrete by subjecting it to a vacuum was tried out with some success.

An important development in the field of cement was the adoption of a new definition incorporated in the A.S.T.M. high-early-strength specification which permits the addition up to 1 per cent of materials other than gypsum; grinding agents and admixtures to improve workability, assume high early strength or correct excessive bleeding are examples. At Bonneville Dam, the army engineers continued to report satisfaction with the use of portland-puzzolan cement.

New Alloy Steels Activity as it affected steel was most notable in discussions of the new low-alloy proprietary products that have come on the market in considerable numbers. So far in this country their principal use has been in railroad rolling equipment.

The A.S.T.M. is continuing work on a specification for manganese-steel rivets suitable for silicon-steel structures. The final report on the tests of the heat-treated wire salvaged from the Mount Hope bridge cables gave the cause of failure as the inability of the crystalline structure of the wire to resist fatigue fractures under fluctuating tensile loads, while surface imperfections were found to have hastened the spread of fatigue cracks.

Foundation Progress In foundations the year witnessed a greatly increased acceptance and use on the part of field men of the laboratory results of soil studies. Advance in soil mechanics is covered fully in Prof. Casagrande's article on p. 000. Several new construction methods were used on bridge foundations. In sinking large pneumatic caissons for the Pennsylvania Railroad lift bridge at Newark, N.J., the contractor belled out the bottoms with the aid of H-beams driven on an incline around the working chamber and carrying wood lagging to hold the ground, thus eliminating the usual cumbersome timber supports. Steel cylinder caissons fitted with a sawtooth cutting edge and internal jet pipes were sunk by boring to a depth of 100 ft. below water level for the piers of the 600-ft. tied arches of the new bridge at Middletown, Conn. Similar methods were used for some of the piers under the west side elevated highway at New York.

Industrial Buildings Only two skyscrapers were added to the nation's skyline in 1936, a 34-story office building in Rockefeller Center, New York, and a 32-story city hall in Kansas City. The most notable public building of the year was the huge Department of Interior edifice in Washington, D. C. Industrial buildings were the star performers of the year, setting new precedents both in design and in materials utilization. Welded girders to carry a 200-ton crane were designed to resist a moment of 42,000,000 in-lb. in a factory near Chicago. Glass blocks were widely accepted for walls and in several instances were used to replace windows entirely. A windowless limestone wall was built in Hershey, Pa. Light-weight floors of steel plate and gypsum were more widely used. Welded framework is becoming commonplace, particularly for trusses; one new building used welded rigid-frame bents. Sawtooth monitors were applied to an arch roof at Santa Monica, Calif. A concrete shell roof 3½ in. thick was built on a span of 220 ft. at Hershey, Pa.

Building and Codes Adoption of the American Concrete Institute building code introduced an outstanding change in reinforced column design. The closely allied work of the joint committee on concrete and reinforced concrete formulating its new report was brought near completion. Steel unit-stresses were revised upward to a 20,000-lb. base by the American Institute of Steel Construction. The new building code committee of the American Standards Association, heir to the U. S. Department of Commerce work, made progress in outlining a program for determining proper working stresses for all building materials. The American Society of Civil Engineers wind stress committee departed from its previous studies of high buildings to render a significant report on the design of rounded and sloping roofs, taking into account local variations in suction and positive pressures. Detroit adopted its building code, but Chicago, Boston and New York could not cut the political red tape.

Earthquake Protection In California the improvement in design standards that followed the 1933 Long Beach earthquake now has become well established. The higher structural standards incidental to seismic resistant design have been studied, used and improved until a new technique has been developed. The cost addition is found to be low.

Jobs and Machines

Work for Engineers The economic position of the civil engineer and construction man continued to improve during the year. A year ago there was some doubt as to whether the improvement then noted was due so much to business revival as to pressure put on the cities by the Public Works Administration late in 1935 to get their PWA projects in shape for contracts. Now few civil engineers are out of employment, and there are reports that there is a shortage of men for higher positions. In the fall the Professional Engineers Committee on Unemployment, largest of the emergency employment agencies set up during the early days of the depression, closed up its activities after four years of work.

Construction Equipment As construction emerges from the lean years of depression it finds a new array of equipment, tools and materials at its disposal. Though the sales and production departments of manufacturers have been marking time, the design and planning divisions have not been idle. The most marked trend is toward rubber mounting of haulage equipment. The perfection of the large, low-pressure pneumatic tire

has made possible the development of large-capacity haulage and tractive equipment capable of high-speed operation. Yet the pneumatic tire has also found a field in portable compressors, pumps, welders and even in hand-pushed concrete buggies.

Of equal importance and significance is the swing toward diesel. Its low cost of operation is its salient characteristic. A third trend is toward high-strength and light-weight alloy. Every pound saved means more economical operation; every item of increased strength means longer life and better operation. The fourth major trend of construction machinery is toward easier operation. Frictionless bearings are becoming standard in most equipment. Power control, both mechanical and hydraulic, is replacing handcontrol, lessen human fatigue and increase output.

Dirt Moving and Roadbuilding

In excavating and earth moving machinery the power shovel has gone to increased output. In haulage, the carrying scraper vies with fast, large-capacity hauling units. Self-loading and self-dumping scapers move thousands of yards of earth daily. Huge tractor wagons mounted on crawlers or rubber tires fill the need of high-yardage production.

Roadbuilding equipment has been increased by subgrade finishers, stabilized mix units, suboiling machines and high-speed concrete pavers. Surface finishers and mechanical screeds meet the need for precision construction in highways. Pumps, hoists, welders, rock drills, detachable bits, air compressors, well points and other tools have been improved correspondingly.

The Business of Contracting

The contracting business entered better days with the growth in construction volume. At best, however, it lacked much of being the comparatively stable activity of predepression days; a symptom may be seen in some notable defaults and abandonments of contracts that occurred during the year. Much uncertainty arose come from legislation and unsettled labor conditions. The price discrimination act, the Walsh-Healy government contracts act, the social security tax law and WPA construction operations helped to disturb contracting. Within itself the business has had to contend with a shortage of skilled labor and problems of subcontractor relationship, particularly in connection with labor relations.

Construction Technique

Improvement in the technique of construction operations is emphasized both by bold venture into wholly new procedures and by the steady betterment of old methods and practice. At Grand Coulee Dam for example a huge earthside slide was checked by freezing the toe into an arch dam. Freezing to stabilize earth is not exactly new, but the Grand Coulee case is notable for ingenious application of freezing to a most difficult problem and on such a large scale. Other examples of new construction procedure include the spinning of caissons to rock for the New York federal building and the Connecticut River bridge at Middletown, and the pumping of pulverized sandstone in excavating the Twin Cities sewer tunnels.

Betterment of old procedures was evident on the Grand Coulee and Bonneville Dam cofferdams; also in the well-point drainage work at Imperial Dam, probably the greatest job of its kind ever performed. Dredging at Fort Peck has far surpassed any hydraulic work of the past. The methods of spinning cables on the two San Francisco bridges mark historic advance in suspension bridge building. And improvement in technique is not confined solely to the large projects, but is noticeable on the common, every-day job as well.

Some Related Happenings

Practically every industrial development has civil engineering significance, and some, particularly in the power and transport field, are quite obvious in their implications. They deserve a place in this review.

A sensational rise in power use taxed the existing generating capacity of utility and industrial stations; their rush for new equipment has created a jam in manufacturing plants so that 12 to 18 months is best possible delivery for large boilers and turbines, and 6 to 12 months for medium-size units. Developments in generating equipment include a marked increase in high-speed turbines (3,600 r.p.m.); the utilization of hydrogen cooling for the large capacity machines; manufacture of a compact or "packaged" steam plant including all auxiliaries which delivers 1,400-lb. 900-deg. steam and may be mounted on a flatcar, and a growth in the practice of installing super-posed units of high-pressure boilers and turbines in old plants whose existing turbines then operate on exhaust steam from the new units. A sensational power development was the completion of the transmission line from Boulder Dam to Los Angeles; hollow copper conductors were required to carry the 287,000 volts, a new record.

In the field of transit, street car business declined 3 per cent to 76 per cent of the total; city purchases of large buses totaled 4,550 against 2,850 in the previous year. The number of trolley buses bought (545) equalled the total number in service. The program of street car rehabilitation got under way, and 300 of the 400 new cars purchased were of the new design featuring less noise and higher speeds. Passengers on intercity buses incrased by 60 million. Air-conditioned buses made an appearance, and $7,000,000 was spent on new bus terminals.

The railroads spent $727,000,000 for new materials and equipment, 80 per cent more than in 1935. Astonished by the reception given the new high-speed trains, the railroads continued to order more new units; 14 streamliners were placed in service and 10 more were ordered in 1936. Speeds of 60 to 80 m.p.h. are common and several trains reach 125 m.p.h. on daily runs.

Bigger, faster transport airplanes continued to be built, requiring larger, longer and better landing fields. More people used them, emphasizing need of increased passenger handling facilities at airports. WPA funds amounting to some $18,000,000 were used on nearly 400 airports, to bring them up to reasonable standards of efficiency.

E.C.P.D. and Education

Most notable among professional happenings was the start of engineer-school accrediting by the Engineers Council for Professional Development. Outside of a very limited amount of vocational guidance work this is the first active step in the large program that the council has adopted.

No new registration laws for engineers were passed during the year, a law was defeated in Kentucky.

Headlines of 1936

Compiled from Current News Pages of Engineering News-Record

JANUARY

MUNICIPAL SUBWAY at New York, the $17,000,000 Houston-Essex St. line, opens.

FLORIDA'S WATER SUPPLY will not be affected except locally by construction of the Florida Canal, a War Department board of geologists and engineers reports.

SILICOSIS at the Hawks Nest hydroelectric project made the subject of a Congressional investigation, in the course of considering a bill providing for an inquiry into silicosis conditions in construction work introduced into the House by Congressman Vito Marcantonio. Sensational charges made. *See also similar entry under February, below.*

DIVERSION TUNNEL driving and lining contract at Fort Peck relinquished by Mason & Walsh by mutual agreement with the government after it proves impossible to agree on a price for doing the work under changed plans. Government arranges to complete the tunnel by day labor.

OVERTON BILL introduced in the Senate carrying authorization for expenditure of $275,000,000 for completion of flood control work on the Mississippi River. *See April, May, June.*

ELWOOD MEAD, commissioner of reclamation since 1924, dies.

FLORIDA CANAL will not be a self-liquidating project, PWA reports.

SIXTH AVENUE SUBWAY work in New York begins under first construction contract.

▼

FEBRUARY

GILA VALLEY PROJECT in Arizona gets under way again when Secretary Ickes orders resumption of work after the Department of Agriculture withdrew its claim that the project was uneconomic.

PASSAMAQUODDY, Florida Canal, Conchas Dam, the Sardis reservoir, and Bluestone Reservoir dropped by the House appropriations committee from the rivers and harbors appropriation act. *See March.*

HAWKS NEST tunnel contractor, Rinehart & Dennis Co., refuses to appear before the House committee investigating silicosis, denying all charges.

CHICAGO SANITARY DISTRICT refused permission by the War Department to construct a gate at the mouth of the Chicago River to prevent pollution of Lake Michigan; the War Department recommends a lock.

TVA MAY TRANSMIT surplus power generated at a dam built for legal purposes, the U. S. Supreme Court holds. Wilson Dam, according to the Court, was legally built.

DUKE POWER CO. refused an injunction against construction with PWA funds of a hydro-electric power plant in Greenwood County, S. C., by the U. S. Circuit Court of Appeals; decision reverses district court. *See Dec.*

POWER AGENCY for the Columbia Basin recommended to Congress by the Pacific-Northwest Regional Planning Commission.

DEEP SNOW throughout the country causes Weather Bureau to express fear of high floods in the spring. *See March.*

TEN DAMS on tributaries of the Connecticut River, to cost $13,373,000, recommended by the board of engineers for rivers and harbors.

▼

MARCH

SUITS PENDING before the U. S. Supreme Court to determine the right of the PWA Housing Division to condemn land for housing projects dismissed at the request of the Department of Justice; reason given: no funds available for the purchase of land.

INJUNCTION against flood control and power generation projects on the Brazos and Lower Colorado Rivers sought from the District of Columbia Supreme Court by Texas utility companies. *See Dec.*

PWA APPROVES grant of $11,200,000 and a loan of $47,130,000 to New York City Tunnel Authority for construction of a tunnel under the East River from Manhattan to Queens.

FLORIDA CANAL appropriation rejected by the Senate but approval granted to Sardis, Conchas, and Bluestone projects.

FLOODS do much damage in Pennsylvania, Maine, New Hampshire, Connecticut and New York. Record stages reached on Susquehanna, Connecticut, and other rivers in northeastern states. President Roosevelt appoints an emergency flood committee and allots $43,000,000 from WPA funds for repair of flood damages.

RIGHT TO CONDEMN land for slum clearance by New York City Housing Authority upheld by the New York State Court of Appeals.

▼

APRIL

TORNADOS at Tupelo, Miss., and Gainesville, Ga., and Greensboro, N. C., and Cordele, Ga., do damage estimated at $10,000,000.

PRESIDENT ROOSEVELT states he will allot no funds to the Florida Canal or Passamaquoddy unless they are approved by Congress.

OVERTON FLOOD CONTROL bill passes Senate.

TOPOGRAPHIC MAPPING program for the United States to be drawn up by the Secretary of the Interior under the terms of a resolution passed by the Senate.

MAY

ELK CITY DAM in Oklahoma fails.

RELIEF WORK BILL passed the House carrying appropriation of $1,425,000,000 and no provision for PWA.

MUNICIPAL BANKRUPTCY ACT of 1934 declared unconstitutional by the U. S. Supreme Court.

ARIZONA refused permission by U. S. Supreme Court to file suit for a determination of its rights to Colorado River water.

RELIEF WORKS BILL passes the Senate carrying an appropriation of $1,425,000 and providing $300,000,000 for PWA; bill disqualifies projects for which allotments made by the President are not sufficient for completion but includes provision for $10,000,000 for the Florida Canal if a board of three engineers reports favorably on the project; includes no provision for Passamaquoddy; provides $57,000,000 for reclamation projects, including $20,000,000 for Grand Coulee.

FIRST BIDS for New York's 1939 World's Fair received, covering grading of site.

TVA CLAIMED TO BE unconstitutional in suits entered by nineteen Southern power companies in U. S. District Court at Birmingham and in State Chancery Court at Knoxville, Tenn. *See July, Aug., Sept., Dec.*

▼

JUNE

OVERTON AND OMNIBUS flood control bills approved by House and Senate go to President for signature.

DELAWARE RIVER WATER SUPPLY provided for in an authorization by the New York City board of estimate of an appropriation of $17,500,000.

INTERSTATE COMPACTS for flood control between New England and Ohio Valley states authorized in a joint resolution signed by President Roosevelt.

PWA ALLOTMENTS for power plant construction to ten municipalities in Alabama, Texas, Oklahoma, and Iowa upheld by the District of Columbia Supreme Court.

SILICOSIS CONTROL provided for in three bills signed by the governor of New York; the bills limit compensation for silicosis to $3,000, call for the use of dust control devices in all dangerous industries and appropriate $150,000 for research and enforcement.

OVERTON FLOOD CONTROL bill signed by President Roosevelt.

WAGNER PUBLIC HOUSING bill passes the Senate, authorizing expenditure of $150,000,000 per year for three years.

CONFERENCE REPORT on Interior Department appropriation bill approved by the House. The House version had made no provision for western reclamation projects, Senate version had pro-

vided $57,000,000; compromise was reached in conference on $31,610,000.

COLLAPSE of an apartment house under construction in the borough of the Bronx, New York City, kills seventeen workmen and injures eight. *See July.*

PERMANENT TRAFFIC COMMISSION for New York State provided in a bill signed by the governor.

BROADWAY HIGHWAY TUNNEL at Oakland, Calif., abandoned by the contractor, Six Companies of California, who claims ground conditions are not as represented. *See July, Sept., Oct.*

WAGNER LABOR ACT held unconstitutional by the Sixth U. S. Circuit Court of Appeals at Cincinnati.

DANGER of serious drought seen in the Middle West and South Central States. *See July, Aug.*

OMNIBUS FLOOD CONTROL bill signed by President Roosevelt.

PRESIDENT VETOES a bill to permit federal aid highway funds to be used for the purchase of toll bridges.

WALSH-HEALY bill setting wage and hour standards for all government contractors signed by President. *See Sept.*

▼

JULY

DROUGHT CONDITIONS widespread throughout the grain states and worse than at the same period in 1930 and 1934. Plans being made for removal of families from regions worst hit. West of the Mississippi surface and ground waters approaching all-time lows.

KETTLE FALLS development on the Columbia River forbidden by the Federal Power Commission on the ground that it will interfere with federal development of the river.

BROADWAY HIGHWAY TUNNEL contractors, Six Companies of California, file a $3,296,000 breach of contract suit against Joint Highway District No. 13 at Oakland, Calif., the owner.

TRIBOROUGH BRIDGE opened to traffic.

FLOOD of record intensity in Guadalupe River Basin in Texas causes damage estimated at $13,000,000.

UNSATISFACTORY BIDS on housing projects lead PWA Administrator Ickes to threaten force account work.

APARTMENT HOUSE COLLAPSE in the Bronx leads to the indictment for manslaughter of the architect, the builder, a masonry contractor, and two employees of the Bronx bureau of building.

REGISTRATION of all general contractors holding contracts for more than $10,000 required by Louisiana legislature.

POWER GENERATION begins at TVA's Norris Dam.

NINETEEN POWER COMPANIES suing TVA in Tennessee Chancery Court at Knoxville transferred their case to the Federal District Court in Nashville.

▼

AUGUST

DROUGHT CONDITIONS held to be the most severe in the history of the United States. Water shortages and record low streamflows common throughout the western drought area. In many of the eastern states, despite no serious hardship, many rivers approach or drop below record low flows. Rains in the middle of the month definitely end the emergency in the east and materially improve conditions in the western drought area.

DAMAGE SUIT for $2,600,000 brought three years ago by the Los Angeles Flood Control District against the contractors on the original and abandoned San Gabriel Dam No. 1 settled out of court for $738,000.

PLANS APPROVED BY NEW YORK CITY TUNNEL AUTHORITY for a Mid-town vehicle tunnel under the East River from Manhattan to Queens.

FLOOD CONTROL projects in Pennsylvania, Maine, Massachusetts and West Virginia receive WPA allotments of $4,288,000.

HOUSEBUILDING to the number of 1,320,000 units annually for the next ten years held necessary by the American Federation of Labor.

SEWAGE POLLUTION ABATEMENT in the Ohio River by interstate treaties urged by Governor Davey of Ohio, who asks governors of seven state to appoint a commission to draft a treaty. *See Nov.*

FLOOD CONTROL work allotted $11,982,000 by the War Department.

BIDS REJECTED on a Washington, D. C., housing project. *See Nov.*

GREAT PLAINS drought area committee reports, urging continued and accelerated federal measures to conserve water and encourage better farming practices.

▼

SEPTEMBER

NINETEEN POWER COMPANIES abandon suit against the TVA in the Birmingham federal district court but continue to press their suit in the federal district court at Knoxville.

BIDS REJECTED by the New York City board of transportation on the section of the Sixth Ave. subway between 33d and 40th Sts.

THIRD WORLD POWER CONFERENCE held at Washington, D. C.

FIRST POWER generation at Boulder Dam by an auxiliary 3,500-hp. generator.

RECORD FLOODS on the Concho and Colorado Rivers in Texas cause damage estimated at more than $3,000,000.

NO BIDS RECEIVED for completion of the Broadway highway tunnel by highway district at Oakland, Calif.

WALSH-HEALEY ACT does not apply to construction contracts, regulations issued by the Department of Labor indicate.

ANOTHER FLOOD strikes in Texas on the Brazos River and its tributaries, the Leon, Little, and Lampasas. Damage estimated at $8,000,000.

QUABBIN RESERVOIR CONTRACTS held by Two Companies, Inc., and Cendella & Co. declared void by Massachusetts attorney general because of irregularities in their award.

▼

OCTOBER

EAST RIVER VEHICLE TUNNEL from Manhattan to Queens put under construction.

BIDS REJECTED on a Detroit housing project. *See Dec.*

REHEARING of the Colorado River water suit denied to Arizona by the U. S. Supreme Court.

BIDS REJECTED on a Schenectady housing project. *See Dec.*

BROADWAY HIGHWAY TUNNEL contract awarded to the George Pollock Co. and R. G. Clifford by highway district No. 13 at Oakland, Calif., on second advertisement.

SOCIAL EMPHASIS in engineering education urged by President Roosevelt in a letter to presidents of engineering schools.

BIDS REJECTED on a housing project at Evansville, Ind.

▼

NOVEMBER

FLORIDA CANAL justified in the public interest, a special board of officers of the U. S. Engineers reports.

HOUSING PROJECTS at Nashville, Tenn., and Minneapolis, Minn., redesigned for lower costs after bids have been rejected. Contract for a project at Washington, D. C., awarded on the second bidding when more satisfactory bids were obtained.

OHIO VALLEY STATES form a commission to draw up an interstate treaty for abatement of pollution of the Ohio River.

IMMEDIATE CONSTRUCTION of the second tube for the Midtown-Hudson vehicle tunnel from Manhattan to New Jersey voted by the Port of New York Authority.

▼

DECEMBER

REDESIGN of a Detroit housing project ordered. Bids were rejected in October.

DAMAGES arising from government delays in the construction of a post office at Trenton, N. J., awarded to the Carnot-Smith Co. by the U. S. Court of Claims.

DUKE POWER CASE questioning the constitutionality of PWA loans to municipalities for public power projects returned to the lower courts by the U. S. Supreme Court because of irregularity in procedure.

TEMPORARY INJUNCTION against further expansion of the TVA power facilities pending decision in the case brought against TVA by nineteen power companies granted by the U. S. District Court at Nashville.

REDESIGN of a housing project at Schenectady ordered. Bids were rejected in October.

BRAZOS RIVER flood control and reclamation project held up by an injunction restraining the use of federal funds on dams of the project, granted by the Supreme Court of the District of Columbia.

FEDERAL AID highway apportionments to the states of $200,000,000 for the fiscal year beginning July 1, 1937, announced.

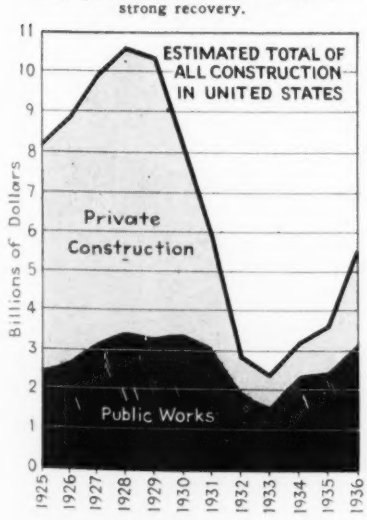
Construction Nears Six Billions

Active private building in 1936 in the face of rising costs carried the construction industry more than 50 per cent beyond 1935 and close to two-thirds normal volume

EXCEEDING all advance predictions by a substantial margin, 1936 construction contracts reported by *Engineering News-Record* went above the previous year's figures in nearly all branches and in every geographical region of the country. Estimating the country's total from these reports we place the 1936 construction volume at 5.6 billion dollars. Compared with the 1932-33 average, which on the same basis of estimate was 2.6 billions, the present level is about 130 per cent above that touched at the bottom of the depression and is almost equal to the 1931 level of construction activity. Thus the industry has reached two-thirds of normal volume—which on comparable basis may be set at 8½ billions. It is significant that this increase has come despite a marked rise in construction costs, which now stand at the highest levels since 1924.

A prominent feature of the year's economic history is that construction, in company with others of the heavy capital-goods industries, advanced at much faster rate than did manufacture and general business. The Federal Reserve Board index shows that manufactures gained 15 per cent over 1935, while the *Business Week* index shows a 14 per cent gain in general business activity. The fact that construction increased more than three times as much (see the accompanying charts in Fig. 2) is mainly due to its greater depression decline. For the same reason, there is more left to be made up in 1937 and 1938.

FIG. 1—A STEADY THREE-YEAR RISE has carried the construction volume to the 1931 level. While public works still hold leading position, private construction made a strong recovery.



Large gains in private work

It is important to examine the chief elements of the 1936 construction advance. A steady increase in private work, which doubled the previous year's volume, was the characteristic of the 1936 record. In pre-depression years private construction was the mainstay of the industry, accounting for two-thirds of the total volume. From a depression low of 24 per cent private construction has now returned to a level of 44 per cent of the total. In breaking down the estimate of 2½ billions of private construction in 1936, we find that about one billion dollars is in residential construction, involving close to 200,000 family units, more than double the volume of 1935. An equally significant rise took place in private engineering construction, where heavy industrial expansion and an unexpected upturn in commercial building activity raised the total estimate to 1½ billions, a 95-per cent gain over the previous year.

TABLE I — ESTIMATE OF ALL CONSTRUCTION IN THE UNITED STATES

(Millions of Dollars)

	Public	Private	Total
1925...	2,476	5,702	8,178
1926...	2,670	6,208	8,878
1927...	3,073	6,522	9,595
1928...	3,480	7,100	10,580
1929...	3,263	7,114	10,377
1930...	3,363	4,695	8,058
1931...	3,098	2,832	5,930
1932...	1,918	921	2,839
1933...	1,533	907	2,440
1934...	2,373	731	3,104
1935...	2,460	1,221	3,680
1936...	3,140	2,450	5,590

Further evidence of the rising trend in private construction is reflected in the steady upturn in building permits. In 1936, permit figures reported by Dun & Bradstreet for 215 cities amounted to $968,000,000, about the 1931 level and a gain of 62 per cent over 1935. Permits issued the last half of the year were considerably above those of the first six months, and the seasonal decline toward the end of the year was smaller than usual. A 12-year trend of building permits is shown at the top of the accompanying page of charts.

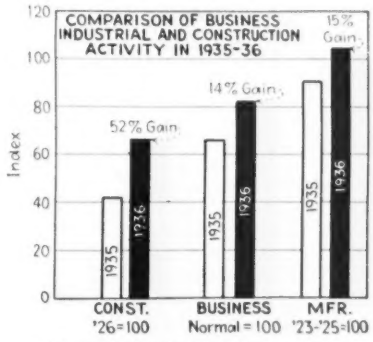


FIG. 2—CONSTRUCTION showed a greater gain last year than did general business or manufactures, but because of its greater depression drop has further to go to reach normal.

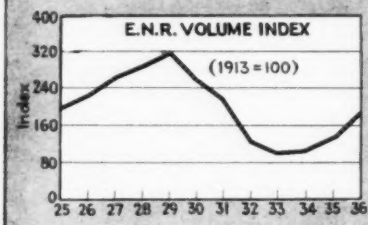
Public works also gain

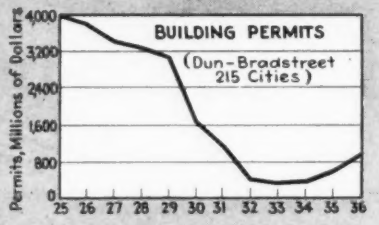
Not the whole story of the 1936 construction gain lies in private work, however, for public works increased 28 per cent to reach an estimated total of 3.14 billions, the highest level since 1930. State and municipal construction activity was responsible for the entire gain in public works, for federal operations fell off somewhat from the previous year's all-time high peak. Public buildings, highways, bridges and grade crossings were the principal items in the public works volume. The year 1936 saw fewer large federal projects started than did the previous year, which accounts for the decline in this class of work, though operations prosecuted by the national government remained at a high level.

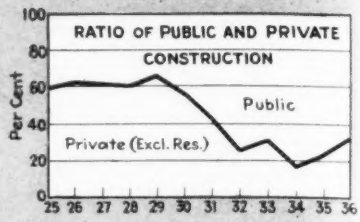
Analysis by classes and districts

For further analysis of the year's construction activity we turn to the reports of contract awards and day labor operations compiled by *Engineering News-Record*. It must be kept in mind that these reported figures differ from the estimated figures given previously in this article, for while

TREND OF CONSTRUCTION SINCE 1925

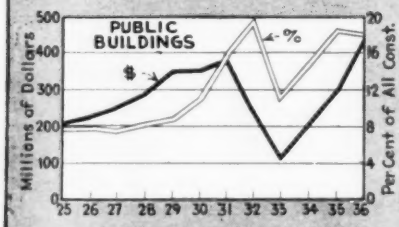


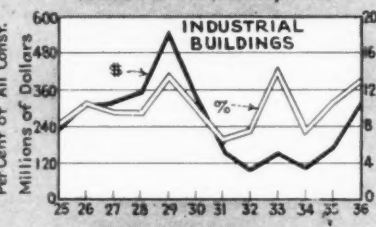


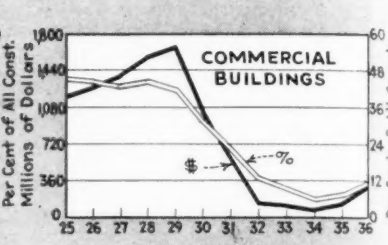


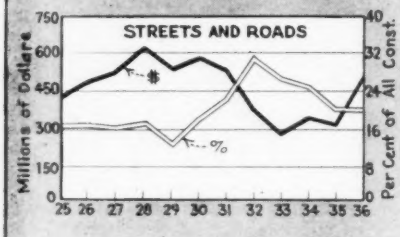
TREND OF CONSTRUCTION BY CLASSES

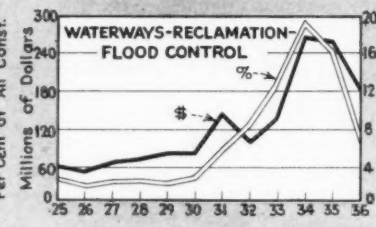
(Based on E.N.R. Reports)

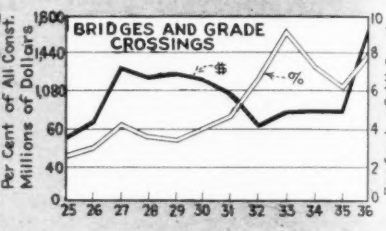


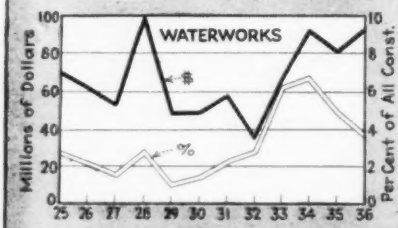


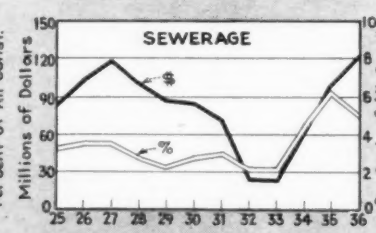


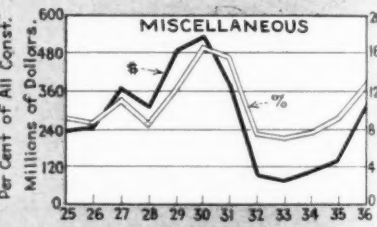






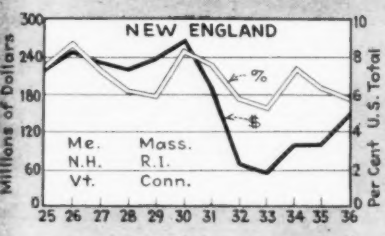


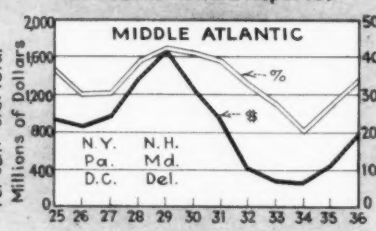


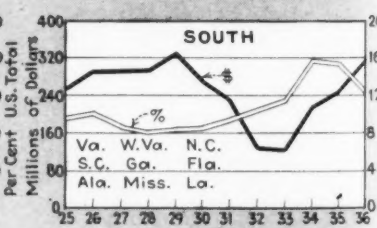


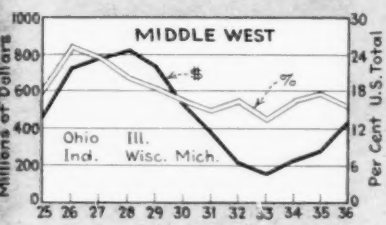
GEOGRAPHICAL DISTRIBUTION OF CONSTRUCTION

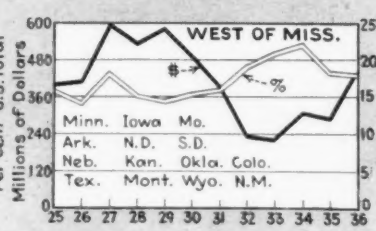
(Based on E.N.R. Reports)











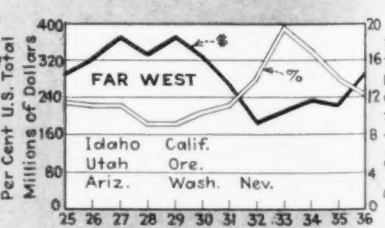


TABLE II — ENGINEERING CONSTRUCTION CONTRACTS REPORTED BY *E N R* IN 1936

(Thousands of Dollars)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States 1936	United States 1935	% change	Canada 1936	Canada 1935
Public Works											
Waterworks	8,073	10,538	8,887	14,325	20,267	30,338	92,478	80,677	+15	2,032	2,987
Sewerage	7,052	38,444	5,892	47,089	16,693	5,886	121,056	99,935	+21	2,008	1,266
Bridges, public	18,529	44,266	18,216	28,323	48,098	16,317	173,749	86,861	+100	5,104	2,387
Earthwork and waterways	7,933	26,299	50,462	16,927	52,566	27,498	181,685	258,740	— 30	3,935	16,375
Streets and roads	27,664	94,592	88,632	87,500	128,595	56,492	483,475	325,263	+ 49	25,513	16,113
Buildings, public	38,192	138,579	49,954	75,688	82,798	50,715	435,926	297,858	+ 47	6,685	15,555
Unclassified, public	11,811	76,985	7,122	8,909	11,258	16,386	132,469	69,678	+ 90	5,443	8,814
Total public	119,254	429,703	229,165	278,759	360,275	203,682	1,620,838	1,219,012	+ 33	50,711	63,497
Federal gov't (incl. in above classifications)	18,047	73,003	81,477	42,054	68,096	36,861	319,538	362,265	— 12	.....	.....
Private											
Bridges, private	414	9,791	131	1,237	871	1,623	14,067	11,072	+ 13	70	25
Buildings, industrial	15,424	84,527	50,170	96,519	32,602	30,225	309,477	172,467	+ 79	33,443	10,933
Buildings, commercial	11,238	211,667	9,791	18,233	8,441	15,414	274,784	108,817	+152	4,466	5,799
Unclassified, private	1,965	40,071	19,478	28,387	42,789	34,989	167,679	78,783	+112	5,103	754
Total private	29,041	346,006	79,470	144,376	84,703	82,251	766,007	371,139	+107	43,082	17,511
Grand total — 1936	148,295	775,769	308,735	432,135	444,978	285,933	2,386,845	.....	+ 50	93,793	.....
Grand total — 1935	101,631	441,940	245,303	280,494	295,136	225,647	.....	1,590,151	.....	.....	81,008

they form the basis upon which the estimates are made, they represent only a part of the estimated totals. Our reported figures exclude individual residential building, as well as work of all classes under certain minimum construction costs. The reports are consistent from year to year and provide an excellent index of engineering construction operations.

Engineering construction as reported by *ENR* in 1936 amounted to $2,386,000,000, of which 1.6 billions was public works, while more than three-quarters billions was private. Compared with 1935, the year's total volume gained 50 per cent; public works increased 33 per cent, while private operations more than doubled with a rise of 107 per cent. Yet, despite the high public works element, private construction accounted for 32 per cent of the total volume, an encouraging increase from the 18 per cent ratio of only two years ago.

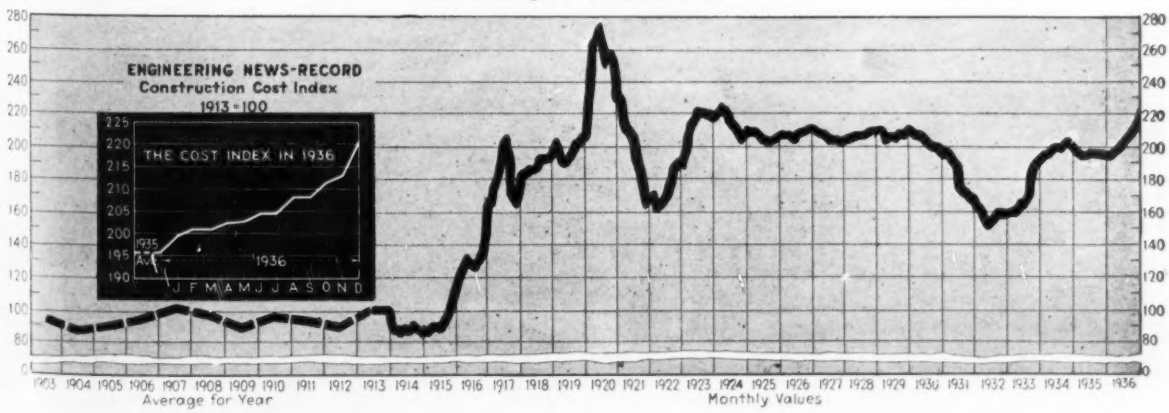
Road and street construction led in volume all of the seven classifications into which public works are divided in our report, while bridges and grade crossings showed the greatest proportional rise over the previous year's figures. Street and highway work amounted to $484,000,000, an increase of 49 per cent. Bridges and grade crossings aggregated $173,700,000, which represented an increase of 100 per cent. Activity in four major elements of public works—bridges, buildings, waterworks and sewerage—reached record high levels in 1936. Miscellaneous operations, not otherwise classified, also reached a high total, stimulated by airport development, subway and vehicular tunnel work, and parks and playgrounds. The only type of public works to show a decrease from the previous year's volume was waterways, drainage and irrigation, down 30 per cent. This loss is due to a slackening off of large operations of the past two years, such as the western dams, TVA projects, and the Mississippi work. Federal activity showed a slight recession from the previous year's record high.

Industrial building was the largest element in private construction operations, amounting to 309 million dollars, a gain of 79 per cent over 1935. This volume equals that of 1930, and is 77 per cent of the record high year, 1929. Industrial construction has come back faster than any other class of work in relation to its depression low.

Commercial building activity showed a surprising rise in 1936, a gain of 152 per cent to 275 millions. This class of building suffered most during the depression drop, falling from a reported figure of 1.7 billion dollars in 1929 to less than 100 millions in 1934. Miscellaneous private construction showed a substantial gain of 112 per cent to reach $142,000,000. Heavy railroad maintenance and reconstruction was an important factor in this item.

The *Engineering News-Record* Construction Volume Index, which is a measure of physical volume based on 1913 costs and activity, showed an increase of 35 per cent for the year, averaging 185 as compared with the 1935 average of 135 points. A fixed closing date for PWA contracts in January pushed the index that month up

FIG. 4—CONSTRUCTION COSTS advanced sharply last year because of rising materials prices and labor rates. The Cost Index now stands at the highest level since 1924.



to 248, the highest of any month since August, 1930. In May the index reached the year's low of 149. Rising costs during the last half of the year depressed the volume index.

Geographical distribution

The geographical distribution of contracts is of interest. Every one of the six geographical districts into which *ENR* reports are divided participated in the general rise in construction, but the Middle Atlantic industrial district fared the best, reporting 76 per cent gain for the year. Because of the heavy increase in the Middle Atlantic district, the ratio of each territory's contribution to the total construction volume changed somewhat from former years. The 1936 ratios are: New England, 6.2 per cent; Middle Atlantic, 32.5 per cent; South, 12.9 per cent; Middle West, 17.7 per cent; West of Mississippi, 18.7 per cent; and Far West, 12.0 per cent. In relative percentage every district except Middle Atlantic showed a loss for the year. These relative standings show the trend of construction turned eastward to the industrial areas following a six-year swing to the West because of the huge undertakings out there.

A 12-year trend of the various classes of work and geographical distribution of contracts is shown in the accompanying page of charts.

Construction financing

The bright spot in the new production capital picture for 1936 was the jump in corporate issues, which aggregated $251,516,000 as compared with $38,296,000 in 1935. Excluding appropriations for federal work, new productive capital made available for construction during the year totaled $948,000,000. State and municipal bonds amounted to $506,006,000 a 2% gain over 1935.

The drop in public financing for construction purposes as a whole was due to reduced volume of PWA allotments for both grants and loans. The bond market throughout the year reflected the great improvement started early in 1935. In fact, total corporate and municipal financing, as reported by the *Commercial and Financial Chronicle,* for all purposes including refunding amounted to 5.4 billion dollars in 1936, as compared with 3.4 billions in 1935. Total corporate issues last year were 4.2 billions, three and a half times as much as in 1935. (Table III.)

The favorable condition of the bond market is shown by decreasing bond yields in all types of issues. The yield of long-term U. S. government bonds dropped from an average of 2.70 in 1935 to 2.42 at the close of 1936. A selected list of municipals showed a corresponding yield drop from a 1935 average of 3.15 to 2.58 late in 1936. Industrials, railroad and public utility bonds showed a similar decrease in yield during 1936. (Table IV.)

TABLE III — CORPORATE, STATE AND MUNICIPAL FINANCING

(Millions of Dollars)

	Total Financing Incl. Refunding*			New Productive Capital		
	Corporate	State and Mun.	Total	Corporate	State and Mun.	Total
1925	$4,222	$1,400	$5,622	$1,966	$1,352	$3,318
1926	4,574	1,365	5,939	1,824	1,344	3,168
1927	6,507	1,510	8,017	1,784	1,475	3,259
1928	6,930	1,425	8,345	1,568	1,379	2,947
1929	9,376	1,431	10,807	1,758	1,418	3,176
1930	4,757	1,487	6,244	2,032	1,434	3,466
1931	2,371	1,256	3,627	787	1,235	2,022
1932	643	849	1,484	159	561	720
1933	380	520	900§	292†	1,091‡	1,383
1934	490	939	1,429§	77†	1,011‡	1,088
1935	2,267	1,215	3,482§	47†	1,705‡	1,752
1936	4,242	1,114	5,356§	250	698‡	948

* From Commercial and Financial Chronicle.

§ PWA Financing not included.

† Includes $237,000,000 PWA loans, '33; $55,000,000, '34; $9,000,000, '35.

‡ Includes $814,000,000 PWA loans and grants, '33; $580,000,000, '34; $1,208,000,000, '35; $164,700,000, '36.

TABLE IV — BOND YIELDS

	U. S. Treas. (1)	Municipal (2)	Industrial (3)	Pub. Util. (4)	Railroad (5)
1932 Ave.	3.66	4.65	7.46	5.36	5.99
1933 Ave.	3.31	4.71	6.93	5.26	5.65
1934 Ave.	3.10	3.95	5.30	4.61	4.65
1935 Ave.	2.70	3.15	4.61	4.31	4.93
1936 Jan.	2.68	2.93	4.29	4.09	4.63
Feb.	2.62	2.86	4.27	4.04	4.43
Mar.	2.54	2.78	4.32	4.01	4.37
Apr.	2.51	2.76	4.38	4.00	4.45
May	2.50	2.76	4.45	4.04	4.52
Jun.	2.50	2.72	4.44	4.03	4.56
Jul.	2.50	2.70	4.45	4.02	4.58
Aug.	2.43	2.68	4.42	4.02	4.52
Sep.	2.41	2.62	4.40	4.00	4.33
Oct.	2.42	2.58	4.40	4.01	4.24

(1) Ave. all U. S. bonds except those due or callable within 8 years.
(2) Standard Statistics Co.— Ave. 15 high grade long-term issues.
(3) Standard Statistics Co.— Ave. 15 high grade industrials.
(4) Standard Statistics Co.— Ave. 15 high grade public utility issues.
(5) Standard Statistics Co.— Ave. 15 high grade rail issues.

Cost of construction

One of the outstanding developments in construction last year was the steady increase in costs that finally reached a level at the end of the year not touched since mid-year in 1924 when costs were dropping from their post-war peak. The *Engineering News-Record* Construction Cost Index, based on common labor rates and the price of three basic commodities, stood at 199.48 at the beginning of the year (1913=100) and closed at 220.67, a rise of 11.3 per cent. The year's average was 206.40, which is 6 per cent higher than the 1935 average of 195.22. A surge in steel

FIG. 5—STEEL AND LUMBER set the pace in the upward turn of materials prices for 1936, while cement prices were stable.

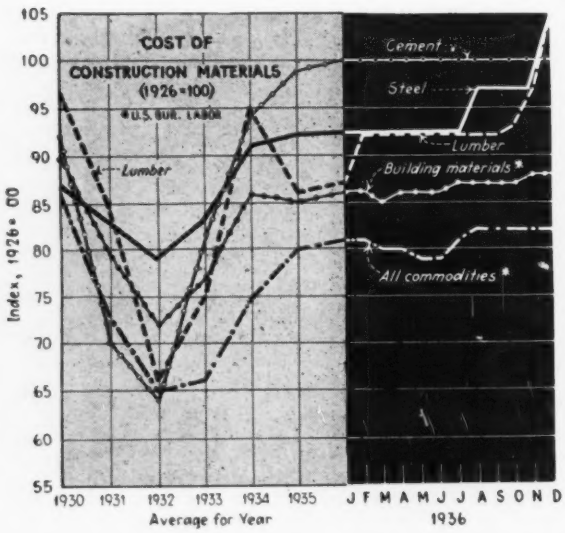


FIG. 6—OUTPUT of construction materials is approaching pre-depression levels.

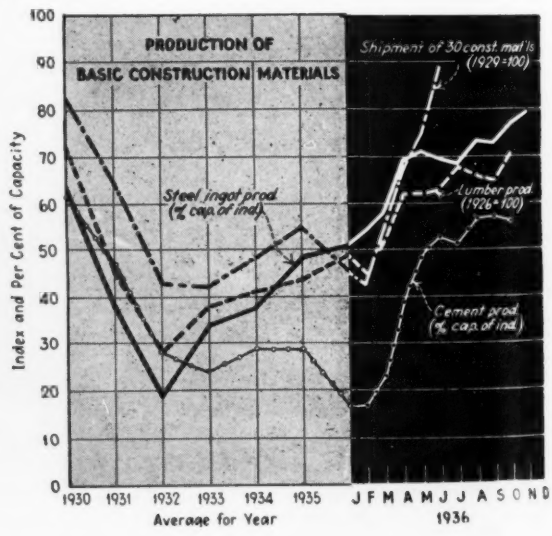


TABLE V — OUTPUT OF VARIOUS CONSTRUTCION MATERIALS FOR TEN-YEAR PERIOD

Item	Basis	Unit	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	Per Cent Gain 36/35
Lumber	Production	Millions Bd.-ft.	34,532	34,142	36,886	26,051	16,523	10,159	13,961	15,039	15,845	21,761	38
Cement	Shipments	Thous. Bbl.	170,928	175,452	169,440	159,558	126,465	80,529	64,086	75,917	74,936	111,789	49
Steel ingots	Production	Thous. Tons	43,777	50,325	54,850	39,595	25,193	13,323	22,594	25,599	33,426	46,919	40
Fabricated structural steel	Shipments	Thous. Tons	2,854	3,122	3,307	2,987	1,812	942	898	1,116	1,105	1,547	41
Fabricated steel plate	New orders	Thous. Tons	500	628	639	569	303	162	198	242	250	451	80
Explosives	Shipments	Thous. lb.	477,324	455,184	484,596	424,920	325,440	227,508	249,366	305,577	297,730	365,863	23
Common brick	Shipments	Millions	.....	.....	.....	.....	.....	.....	.....	.....	952	1,451	53
Sand-lime brick	Shipments	Thousands	205,080	205,320	172,644	102,552	64,500	27,003	12,427	11,170	15,705	29,196	86
Vit. paving brick	Shipments	Thousands	.....	.....	.....	.....	.....	.....	.....	.....	62,528	94,370	51
Prepared roofing	Shipments	Thous. squares	.....	36,540	39,864	27,876	22,592	22,208	23,883	23,594	27,005	31,253	14

* All preliminary figures.

and lumber prices forced the index up ten points in the last two months, nearly half of the year's total rise.

The 1936 rise in the cost index is in marked contrast to the steady level maintained in 1935, when the range was less than four points; it is more comparable to the NRA upturn of 1933 when the index rose 32 points in climbing out of the 1932 low.

Materials prices rise

The rise in the materials component of the cost index was due to price increases in steel and lumber (Fig. 5). Steel, which had remained stationary in price at $1.80 per 100 lb. (Pittsburgh) all through 1935 and more than half of 1936, jumped 10c. in August and another 17½c. in December, closing the year at $2.075, the highest since 1924 and a rise of 15 per cent since July. Lumber, however, showed the greatest rise of the basic commodities used in the compilation of the cost index. Cost of the type and size of lumber used as the index component opened the year at $54, slightly above the 1935 average, and jumped to $57 in February, and rose another dollar in October. In the two closing months the price reached $58 and then $65, an increase of 21 per cent for the year. Cement, which had fluctuated considerably during the past few years, remained at a constant price level of $2.10 (Chicago) during 1936. Common labor rates, the fourth component of the cost index, rose 7 per cent in 1936.

Another indication of rising construction costs is the frequency with which bids during the latter part of the year exceeded the engineer's estimate of cost—made only a few months previously. In a number of recent instances bids on federal projects were so unexpectedly high that they had to be rejected because the appropriations or allotments were not large enough to meet the bid. An interesting example of increasing cost of materials is the comparison of 1933 and 1936 bids for cast iron lining of the Midtown Hudson tunnel at New York—a special case, to be sure, but a significant one. The iron for the second of the two tubes, bought in December, 1936, cost 35 per cent more than did that for the first tube.

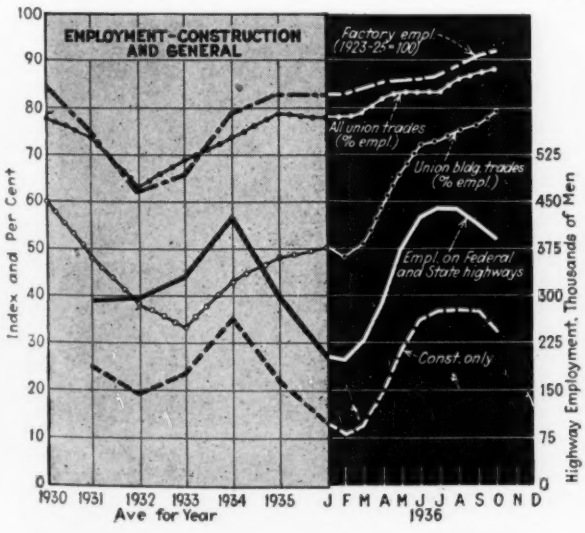
FIG. 7—INDUSTRIAL AND CONSTRUCTION employment gained in 1936, that of building trades workers most strongly. Highway employment was greater than that for the previous year but fell short of the 1934 level.

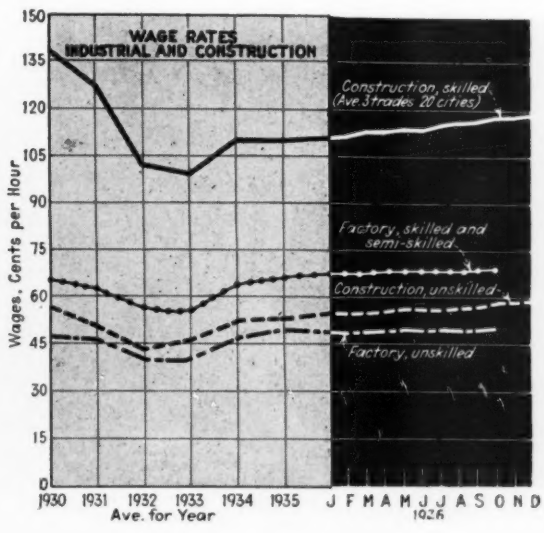
FIG. 8—CONSTRUCTION WAGES rose faster than industrial wages and contributed to rising construction costs.

The 1936 increase in construction costs was not supported by a general price rise, for the U. S. Bureau of Labor cost index of all commodities (1926=100) showed but a slight increase for the year; the index averaged 81.0 as compared with 80.2 for 1935. However, the building material component of this index went along with the upward trend of construction costs, rising from 85.3 to 88.5.

Increased materials production

Production of materials used in construction showed a heavy increase during 1936 (Fig. 6). The figures for ten commodities, shown in Table V, indicate production rises of 14 to 86 per cent. Cement was one of the outstanding items, as the 1936 shipment of 112 million barrels amounted to an increase of 49 per cent over 1935. Lumber production was the greatest since 1930, totaling nearly 22 billion bd.ft., an increase of 37 per cent over the previous year. Fabricated structural steel shipments were at a six-year high, amounting to 1.5 million tons for a gain of 41 per cent. Steel plate fabrication gained 80 per cent for the year. Paving brick likewise showed a substantial gain of 51 per cent during 1936. Steel ingot pro-





duction, at 46.9 million tons, was the highest since 1929, an increase of 40 per cent for the year.

Labor conditions

A threatened shortage of skilled construction workers is the most interesting labor development of the year. The Associated General Contractors report many of their members are having trouble in obtaining competent skilled help, and blame the WPA for creating an artificial shortage. On the other hand, union labor officials deny that a shortage is imminent. The U. S. Employment Service maintains that any shortage of construction mechanics that might exist is due to faulty distribution of the labor supply. It holds that there are enough skilled workers available in the country for all possible work, but that many of them must necessarily be transferred to localities other than their own.

Common construction labor rates in twenty cities as reported monthly by *ENR.* averaged 54.7c. per hr. at the beginning of the year and 58.6c. at the end, indicating a rise of 7 per cent during 1936. Skilled rates in the same cities (average of carpenters, bricklayers and steelworkers) rose from $1.12 in January to $1.18 in December, an increase of but 5 per cent. Construction labor fared somewhat better in hourly earnings than did industrial workers in general, for the U. S. Bureau of Labor reports skilled and semi-skilled labor earnings in 25 industries as an average of 66.3c. per hr. in January, 69c. at the close of the year. In these same industries unskilled labor earned an average of 47.8c. in January and 2c. more than that at the end of the year (Fig. 8).

Employment in both construction and general industry was much improved in 1936 as compared with that of the past few years. The American Federation of Labor reports that about 79 per cent of its building trades members were employed in the closing months of 1936, while only 50 per cent were working at the end of 1935. Employment of all union trades members rose from 78 per cent in January to 88 per cent at the end of the year. In comparison, factory employment, based on 1923-1925 as normal, rose from 82.9 to 93 per cent during 1936. Employment conditions are shown in Fig. 7.

The outlook

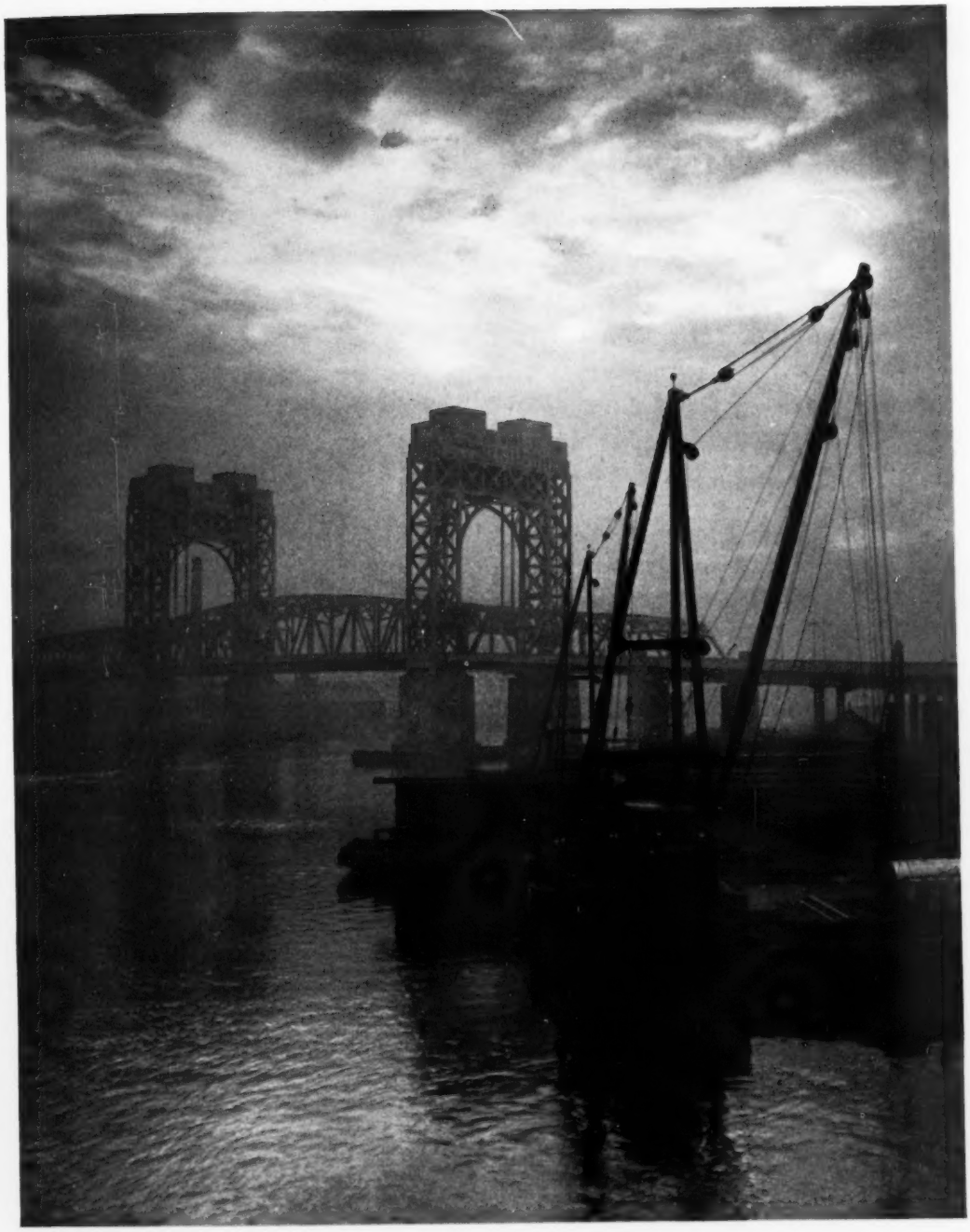
All indications point to a continuation of the upturn in construction volume, though 1937 is certain to see a shift in the relation between private and public work. Public works might fall off somewhat during the year in comparison with the level maintained the past two years. PWA and WPA activity is on the decline, as are also the huge federal projects that have been under way for the past five years. Highways and grade crossings will form a large part of the public works, with indications of a somewhat greater volume than in 1936. If the flood control programs get under way they will also play an important part in public works activity.

Private construction shows great promise for the coming year. Residential building will continue to improve in an effort to reduce the accumulated deficit in home-building. Commercial buildings, which fell the lowest of any class from the boom-day peak, showed surprising strength in 1936. Indications are that this type of building, especially in the smaller units, will continue to increase. Industrial building prospects are likewise encouraging, for a continued rise in industrial activity will call for increased factory building and expansion.

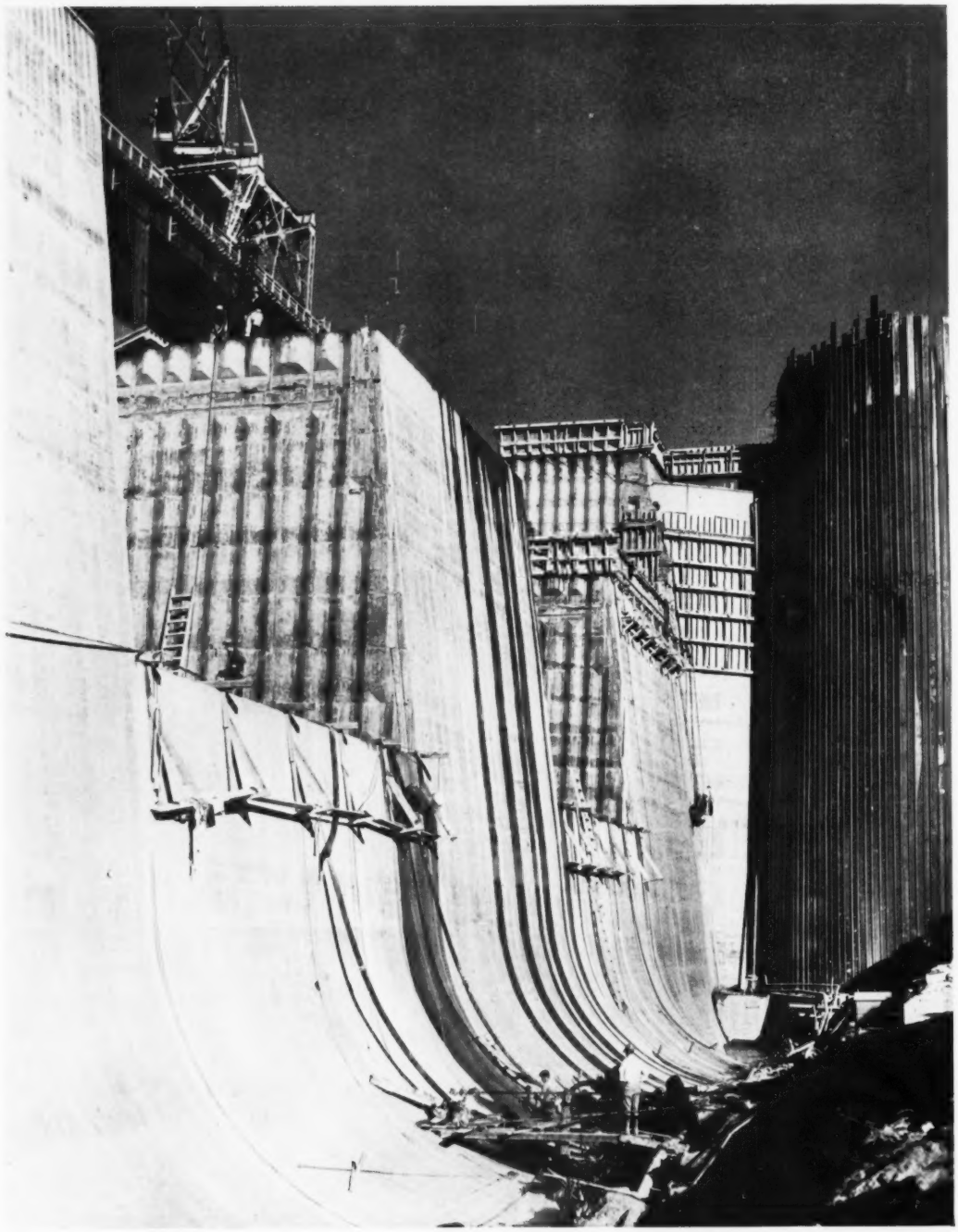
There is every indication to look forward to an increase of another 25 per cent in construction during 1937, which will bring the coming year's total to 7 billion dollars.

McLaughlin Aerial Surveys

ON THE WEST SIDE OF NEW YORK many changes are in progress in the neighborhood of 60th Street. Here shown, running across the picture from the lower left, is the West Side Elevated Highway. In the center (with two white stacks) is one of New York's new incinerators. Near the lower right corner is the New York Central's new depressed rail line which will take that railroad's tracks off 11th Ave., the street in the right foreground.



Harlem River Lift Span, the major element in the Manhattan connection of the Triborough Bridge, New York



Grand Coulee Dam begins to rise above the bed at the Columbia River. The dam ultimately will have a height of 550 ft.

Advances in Selected Fields

The year witnessed special activity in several fields of engineering activity whose advance is here signalized by authoritative analyses and reviews which furnish a basis for estimating the future course of development supplementing the editorial review already given.

RESEARCH, *by*.....*Inge Lyse, Lehigh University*
BRIDGE ENGINEERING, *by*.....*Shortridge Hardesty, Consulting Engineer*
HYDRAULIC PROGRESS, *by*.....*E. W. Lane, University of Iowa*
MUNICIPAL ENGINEERING, *by*.....*W. W. Horner, Consulting Engineer*
SOIL MECHANICS, *by*.....*A. Casagrande, Harvard University*
MATERIALS IMPROVEMENT, *by*.....*H. L. Whittemore, U. S. Bureau of Standards*

Civil Engineering Research

Inge Lyse
Research Associate Professor of Engineering Materials, Lehigh University, Bethlehem, Pa.

RESEARCH in the civil engineer's field showed remarkable activity and achievement during 1936. In particular, growing realization of the usefulness of small-scale models for design purposes as well as for more basic research was made evident by the increased activity in this field. Significant practical accomplishments in soil stabilization and in earth-dam construction re-emphasized the importance of scientific investigation in civil engineering progress. A greater amount of cooperation and coordination of research in concrete and reinforced concrete was promised by the activities of the American Concrete Institute's new research committee, emulating the successful work on welding by the research committee of the American Welding Society.

The past year saw a great growth in the practical use of model study for both research and design.

Experiments with soil stabilization and unprecedented vigor in soil and foundation study are noteworthy phases of 1936 research developments.

Conclusion of the Mount Hope bridge-wire investigation, continued progress in the study of transverse-fissure rail failures, and stress measurement in knee connections of steel rigid frames contributed to the year's brilliant showing.

Materials

Wire, Rails, Impact—Among the outstanding research accomplishments in materials must be mentioned the results obtained at the Bureau of Standards through long-continued experimentation on suspension-bridge cable wire. The unfortunate experiences with heat-treated wire at the Mount Hope and the Ambassador bridges are explained by the grain structure of the wire and the presence of surface imperfections, which caused fatigue failure under alternating stresses of low intensity; cold-drawn wire, because of fibrous structure, was found less subject to fatigue. At the University of Illinois Prof. H. F. Moore continued his valuable contributions to prevention of cracks in railroad rails, shown to be due to "shatter cracks" in the head of the rail. Thermally treated test rails (either control-cooled or normalized) developed no internal fissures—a result foreshadowing great improvement from proper thermal treatment during cooling.

Investigations at the Watertown Arsenal showed that the velocity at which impact tests of metals are made has an important effect on the energy absorbed; each metal has a definite optimum velocity, beyond which the impact value drops off rapidly.

Concrete—In studies by the Portland Cement Association of high-temperature saturated-steam curing, concrete products developed high strengths, but the bond between reinforcing bars and concrete was reduced. Other tests showed that the application of sodium and calcium chlorides for ice removal is detrimental to concrete pavements. Experiments at Iowa State College on bond resistance of high-yield-point reinforcing steel indicated that the bond strength does not increase in proportion to the increase in compressive strength of the concrete, and that deformed bars provide much greater bond than do plain bars.

Useful information on the effect of vibration on the bonding of fresh to hardened concrete and on the bond of reinforcing bars came from the University of Wisconsin, and data on the detrimental effect of heating and cooling of concrete from Kansas State College. The University of California continued its study of puzzolan cements and of long-time plastic flow of concrete, while the University of Illinois reported tests on effect of speed of application of load on strength and elastic properties of concrete. Continued investigations of portland cements at the Bureau of Standards indicated that the poor correlation found between the physical and chemical properties of cement and its calculated compound composition may be due to inaccuracies in the calculation of compound composition.

Model experiments

The expanding use of models in engineering experiments included as a noteworthy item the studies of the Muskingum River flood-control project, where seepage flow through earth dams was investigated and foundation stresses were measured by photo-elas-

tic model tests. At the Bonneville dam project extensive model experiments were made for the design of spillway gates and other structural features; and it has been stated that these studies saved more than ten times the cost of the models. The Bureau of Reclamation made model studies for the design of the spillway and other elements of the Grand Coulee Dam, and the army engineers similarly applied models to the design of the Fort Peck dam.

For the Mississippi River flood-control works, testing was carried out by the army engineers at Iowa University and at the Waterways Experiment Station at Vicksburg. For the Passamaquoddy tidal power project they began model experiments at Worcester Polytechnic Institute on sluice gates, navigation locks and rockfill dams and at their own laboratory at Eastport on corrosive effects of seawater on structures. Model studies on hydraulic structures as well as on rigid-frame and two-hinged arch structures were carried out at the Case School of Applied Science. Massachusetts Institute of Technology produced model-experiment results on sluice-gate discharge.

In the structural field, the behavior of models of tall building frames under transverse load at the University of Pennsylvania and Ohio State University gave valuable information on wind-bracing design. The laboratory of the Aluminum Company of America produced successful results with oversize models (larger than the prototype) in studying such matters as stress concentration at reentrant angles and fillets.

Structural engineering

Experimental research in the structural field has come to be appreciated by the industry as well as by designers. The American Institute of Steel Construction cooperated with the Bureau of Standards in tests of rigid-frame steel assemblages, especially to find the stress distribution in the knee section; the results indicated large departure from straight-line stress distribution in the web at the corner. The A.I.S.C. also cooperated with Lehigh University in studies of the structural behavior of steel-plate bridge floors, which resulted in a rational design method of battledeck floors, and with Columbia University in extensive tests on the stress distribution around the hole in pin-plate connections.

Much experimental work was done on reinforced-concrete members. The Portland Cement Association supported experiments on rigid frames in reinforced concrete at the University of Illinois and on two-way reinforced-concrete floor slabs at Lehigh University. The Rail Steel Bar Association and the Concrete Reinforcing Steel Institute cooperated with the University of Delaware and Lehigh University in studies of the function of the reinforcement in concrete slabs, with particular reference to high yield-point steel and effect of size and spacing of bars. Notable was the finding that size and spacing of bars has no apparent influence on the effectiveness of the reinforcement.

Extensive tests of riveted joints sponsored by the San Francisco-Oakland Bay bridge authority continued at the University of California and at the University of Illinois.

Soil mechanics

The First International Conference on Soil Mechanics and Foundation Engineering, held at Harvard University in June, gave impetus to activity in this field. Correspondingly, rapid advance was made in the practical application of new scientific knowledge to earth dams, foundations and highway subgrades. On the hydraulic side of soil behavior, foundation action under various pressure and moisture conditions was explored, and the materials and construction methods of earth dams studied, with immediate practical application of the results to design and construction.

Soil stabilization in highway construction engaged greatly increased interest, and much experimental work was carried out by many state highway departments, both in subgrade stabilization and in stabilized dirt-road construction. Stabilizing agents such as calcium chloride, cements, tars, etc., are being tried on clay, crushed stone and other natural materials. Thus the soil stabilization problem has opened a new field to civil engineering, a field worthy of extensive research and with high promise of useful practical achievement.

Welding

Welding research of importance to structural engineers was carried out mainly in cooperation with various committees of the American Welding Society. The important problem of fatigue resistance of welded connections moved closer to its solution with the inauguration of experiments of full-size specimens at the University of Illinois and at Cornell University. Heretofore the scant available information on this subject has been mostly of German origin. Experimental data for the design of beam-column connections using seat and top angles with definite end restraint for the beam, which became available from Lehigh University, showed that economic and structural advantages are offered by all-welded connections. Results on built-up brackets gave information for the design of heavier types of beam-column connections.

At the University of Illinois the feasibility of welding the steel frames of buildings to obtain complete continuity was studied; the work showed how rigid windbracing can thus be obtained. Columbia University presented information on stress distribution in fillet-weld joints, obtained by photo-elastic studies on bakelite models.

Outstanding progress in the field of flame cutting of steel was made at the Massachusetts Institute of Technology by the development of high-speed photography of the flame. At Watertown Arsenal valuable information was obtained on arc-welding of structural alloy steel.

Hydraulic Progress

By E. W. Lane

Professor of Hydraulic Engineering, University of Iowa, Iowa City

WITHIN the past few years hydraulic engineering in the United States has advanced at unusually rapid pace, mainly because of direct application of laboratory experimentation to the design of major engineering works. The progress continued during 1936, though perhaps more slowly than in the immediately preceding period, as fewer large projects were started.

At the height of the depression there was a great demand for construction works to relieve unemployment, and many large developments that seemed meritorious were inaugurated. Most of these were well under way by 1936. As only a few additional projects were undertaken during the year, there was less opportunity for advance of the art. It is known, of course, that hydraulic engineering progresses principally in the working out of large developments, for only on such projects are the values involved sufficient to justify the expenditure for thorough study and to demand the originality of approach that leads to major progress.

Much credit for the development of hydraulic laboratory possibilities is due to John R. Freeman, because of his efforts to bring to this country the hydraulic laboratory practice of

Europe. But, as similar progress has been made in other non-European countries and in other fields than hydraulics, it apparently has a much broader foundation than the work of one man.

Only ten years ago practically all the hydraulic laboratories of this country were connected with educational institutions and were used largely for instruction, with a small amount of what might be called pure research. The past decade has seen a great growth not only in college laboratories but also in laboratories for governmental and corporate organizations. The greater part of the work in these laboratories is directed to the solution of problems immediately connected with engineering projects. While this great growth was under way not only were the best current practices of the past generally adopted, but also many new minds were brought into the field, new methods were tried out and new problems attacked. Large funds were for the first time available for the work.

In short, the conditions were favorable for a major advance, and on comparing present-day knowledge with that of ten years ago no one can doubt that a major advance has been made. It seems certain also that the following years will see further progress, but the rapidity of development of the past decade is unlikely to continue in the immediate future. In fact, this is indicated by the 1936 accomplishment, which, although it included some outstanding developments, was on the whole more of the nature of perfecting practices that in their major features had been established by previous investigations.

Rise of model testing

Hydraulic model testing for the spillways of dams and other features of hydraulic projects has become standard practice. There has been a steady increase in the degree of refinement in the construction of the models as experience justified the use (for major structures) of highly accurate models composed largely of metal. Also the technique of forming irregular shapes of transparent plastic material has been well developed, and as this material permits visual observation of the action in the interior of models, where it would otherwise be invisible, its use has led to a much better understanding of complex phenomena such as water flow in the Fort Peck gate towers. Transparent models have given important aid in the study of draft tubes, which were tested in conjunction with model turbines for the wheels at Bonneville and Grand Coulee. It is believed that this arrangement will give more reliable results than testing without the effects which turbines might introduce.

There has been an increasing use of model tests also in connection with other forms of hydraulic machinery, especially big valves and gates. Extensive test work on the hydraulics of navigation locks has recently been completed by the War Department at the University of Iowa. An interesting feature of testing technique for engineering structures used this year at Carnegie Institute of Technology, probably for the first time, is the operation of models in a partial vacuum, which brings the surrounding air pressure into agreement with the model scale and enables certain vacuum effects occurring in the prototype to be observed in the model.

Tidal and silt studies

Extensive work on tidal models has been done during the past year at the U. S. Waterways Experiment Station (Vicksburg), at Massachusetts Institute of Technology, and at the University of California. The elaborate electrostatic and other devices to control the tidal flows in these models and reproduce the natural tidal oscillations accurately are an illustration of what can be accomplished by utilizing recent developments in the electrical engineering field. Studies at Vicksburg to produce materials that would reproduce bed movements with the relatively feeble currents of tidal models have led to elaborate tractive-force tests on materials of wide range of specific gravity. These tests give valuable basic data for use in planning movable-bed model tests, as well as furthering the science of bed load movement.

Because fewer great river projects were undertaken, the advance of hydraulic engineering during 1936 was mainly in perfecting practices established by prior investigations—prominently the fuller development of model testing.

Noteworthy items of the year's work are tidal, lock and gate studies, silt researches, and the Cross solution of network flow.

Flood and drought requirements now are centering attention on hydrologic problems.

Since the work of the movement of solids by flowing water was started in this country a few years ago by Straub and O'Brien there has been a growing interest in this subject, due to its importance in such projects as the Mississippi River improvement, All American Canal and Loup River power project, and in the field of soil conservation. The beginning of what promise to be very valuable studies both in the field of suspended load and bed load have been made by the Soil Conservation Service. A fundamental study of the relation of turbulence to the carrying of silt in suspension is under way at California Institute of Technology in cooperation with the Soil Conservation Service, which should produce a knowledge of this phenomenon which will eventually be of far reaching importance.

Several elaborate sampling installations have been made by the Soil Conservation Service on streams of considerable size by means of which samples of bed load can be obtained at various points across the stream under all conditions of flow, and the magnitude and size range of the load determined. This should go far toward providing accurate quantitative data in this field. An interesting discovery of unusual conditions of flow which may have far reaching importance in the science of hydrodynamics has been made at the National Hydraulic Laboratory in connection with an investigation of the flow of silty water along the bottom of a reservoir filled with clear water.

Plumbing and pipe networks

A development in hydraulic engineering which is not spectacular but promises, because of its multitudinous applications, to bring great public benefit, is the investigation of the hydraulics of plumbing for buildings, which has been carried on by the Bureau of Standards and the University of Wisconsin. An unusual development of the past year has been the solution of one of the oldest problems of hydraulic engineering, namely, the flow in an interconnected system of pipes—a problem for which no very satisfactory solution had heretofore been found. For this hydraulic engineers are indebted to the eminent structural engineer Hardy Cross. His solution is an application of the approach which he has so successfully used in his analysis of rigid frames, and shows the versatility of this method of analysis.

A fitting summary to the recent period of intensive development in the science of the design of high dams was the meeting of the Second Congress on Large Dams. Most of the advance in this field was completed prior to 1936, but information regarding it was made available through this congress. The science of both masonry and earth dams has made exceptional progress during the last decade. The development started first in the masonry dam field, leading up to the Boulder and Grand Coulee dams. Earth dams started later, centering around the dams of the Muskingum system, Fort Peck, Los Angeles, and the Bureau of Reclamation. As masonry dam studies have con-

tinued intensively for about ten years and since no dams of unprecedented size are in view, it is probable that development in this field will not be so rapid in the immediate future. Earth dam research probably has not yet reached its peak, and the next few years may see considerable activity in this field.

Hydrologic advances

The past year has seen notable advance in hydrology. The publication by the U. S. Geological Survey in collaboration with the Water Planning Committee of the National Resources Board of a monograph "Floods in the United States," giving voluminous data on the flood discharge rates of the United States, and its companion volume "Rainfall and Run-off in the United States," represents one of the major contributions to hydrology in recent years. Of similar importance is the revision of the Miami Conservancy District's bulletin "Storm Rainfall of Eastern United States," bringing up to date the information on large storms of this region. A report has recently been issued by the Iowa Institute of Hydraulic Research, in cooperation with the Bureau of Agricultural Engineering and the U. S. Geological Survey, giving detailed hydrologocial observations on the 3 sq.mi. drainage area of Ralston Creek.

Great floods in the northeastern states last March added much to the knowledge of flood runoff and greatly increased the activity in flood-control hydrology. The drought and soil-conservation interest simultaneously centered attention on other phases of water supply and flow. In both these instances the values involved are so great that extensive research seems justified. Much work was done by the War Department to lay the groundwork for extensive research in flood hydrology, and by the Soil Conservation Service to plan and develop measuring devices for intensive investigation of the rainfall and runoff of small watersheds.

As the past few years have seen great advances in the field of dam design and laboratory research for the design of major hydraulic developments, the stage now seems to be set for extensive advance in the next few years in the equally important field of hydrology.

Municipal Engineering

By W. W. Horner

Consulting Engineer and Lecturer on Municipal Engineering, at Washington University, St. Louis, Mo.

PROGRESSIVE RETURN toward normalcy marked municipal public works activity during 1936. In the main it resulted from improvement in the financial position of cities. Not only were budget appropriations strengthened following favorable refinancing operations, but collection of both delinquent and current taxes was better. The extent to which this permitted undertaking deferred public works was somewhat curtailed, however, by continued heavy expenditures for direct relief, particularly in the larger cities.

A distinct tendency toward the initiation of new works projects appeared, due in part to improved finances and influenced to a considerable extent by demands resulting from widespread home building. However, much that is undertaken is being done with federal assistance, and it is likely that independent municipal work will be retarded as long as federal grants-in-aid and work-relief labor remain in the picture.

While the taxpayers' strike (insofar as it relates to the payment of general taxes) seems to have passed, few cities appear ready to undertake improvements that will involve the issuance of special tax bills to finance paving and sewer work, or to resume street widening programs where these would involve benefit assessments against private property. This is one of the most serious conditions with which municipal management is faced, and it may result in the ultimate abandonment of a generally accepted method for paying the cost of pavements and sewer laterals. With respect to financing sewerage extension the tendency is to adopt sewer rental charges, but no satisfactory substitute for the paving tax bill has been suggested. Possibly the assessment method will again become acceptable procedure so far as original paving of minor streets is concerned but the total cost of all repaving and of major thoroughfare improvements will probably have to come out of the general city budget.

Shaking off the lethargy of the depression, says Mr. Horner, cities began a definite return toward normal activity in construction, maintenance and operation of public works during the year just closed.

Finances were better and budgets were increased to take care of growth needs.

Providing means to meet traffic requirements continued to be the principal problem in city engineering, but water supply and sanitation betterments also claimed much attention.

Pavement engineering

Paving programs during the year involved much resurfacing with the use of relief labor. Major thoroughfare construction, where undertaken, has in many instances been an offshoot of state highway activity. The year produced no technical improvement of paving methods of any marked importance, but on the contrary in many cases indicated some relaxation of high standards of technique; this might reasonably be expected in connection with work-relief projects.

In bituminous pavement practice many cities are attempting to produce surfaces of a non-skid type. Where these involve carpet treatments on asphalt mixtures of the older standard types, they seem to be well warranted even though their greater maintenance cost will tend toward increased annual paving charges. To the extent, however, that these surfaces are secured by the laying of open mixtures without adequate seal coats, serious trouble may be expected in the future. There is danger of merely repeating the mistakes of the past, where open mixtures have been found subject to serious raveling; in addition, these mixtures are notoriously unstable, often resulting in washboard surfaces after a few years.

Water supply and sanitation

In the field of water supply and sanitation the educational work of the Public Works Administration during the past three years has left a definite impression. Small cities have been taught what sound engineering involves and the desirability of high standards with respect to both water supply and to stream quality. It seems quite possible that the considerable number of sanitary betterments carried out under the Federal stimulus will be fully matched by the further improvements, a situation in which efforts of state sanitary departments have been strongly influential.

Progress in the field of sewage treatment is exemplified by the better design of small plants. There is also wider use of mechanical equipment in disposal processes. Several small-scale installations give promise of further improvement in trickling-filter practice, especially with respect to the use of high rates of filtration

in connection with aeration, or the recirculation of partly settled filter effluents. It is of interest to note that many state sanitary agencies are devoting considerable effort to improving operation and management of treatment plants. One state in the Midwest has reported that treatment works are being installed as fast as conditions warrant, but that much is to be desired with respect to their operation. Unquestionably, it will be difficult to properly train the large number of new sewage works operators now required, and to convince cities with newly constructed plants of the importance of continuous high-grade maintenance.

In the Middle West, a return to drought conditions in 1936 produced a final conviction that water supplies must be thoroughly revamped for dependability in dry years. In cities of moderate size this situation is accelerating the change from groundwater sources to impounded surface supplies aimed definitely at the capture of infrequent floodflows. In many parts of the country such proposals are obviously not practical as individual municipal enterprises, and cities are joining in a general demand on state and federal authorities for water conservation of the wide-spread type intended to improve run-of-the-stream conditions. Drought conditions have gone far to support the demands of state sanitary departments for complete treatment of waste discharged into small streams.

The increasing use of groundwater in connection with air conditioning is giving further concern in both the waterworks and sewerage field. Numerous instances have been reported where large volumes of water circulated in connection with air-conditioning are discharged to the sanitary sewers, radically changing both the volume and character of the sewage to be treated. In some parts of the Middle West air conditioning installations are drawing on groundwater for cooling to an extent that is greatly accelerating the depletion of supplies.

In the field of garbage and waste disposal much interest is being evinced in the possibilities of grinding garbage and discharging it into sewers. During the year past a number of cities have undertaken studies to determine the possible overall economy of grinding garbage and of carrying the additional load on the sewage treatment works. Where ground garbage is being discharged through the sewers to natural water courses without treatment such practice will obviously advance the time when sewage treatment will be essential.

While it is recognized that much of the large work which has been done in connection with the relief programs was made possible by the extensive planning work of the past, there was no marked resumption of long-range city planning. This was due in part to concentration on state planning movements, and to the inability of the cities to provide funds for this purpose. Considerable work of real value in the inventory and the statistical phases of planning continued to be carried out under work-relief programs, but the material collected has not yet been subjected to detailed analysis.

The more important occurrences of the year have been the revamping of some land-use plans because of renewed activity in land subdivision; further studies of "blighted" areas in connection with housing developments; and consideration of the proposed Neighborhood Protective and Improvement Act, sponsored by the National Association of Real Estate Boards—a symptom of the need for more effective zoning, particularly to protect older residential neighborhoods.

Traffic requirements

With respect to planning for traffic, the present situation is particularly acute; the number of cars attempting to use the streets is constantly increasing and the statement that main thoroughfares will always be used to a point of saturation has been vindicated time and again. The cities have had several years of experience with the major thoroughfares that were so extensively provided during the 1920-1930 decade, and conditions last year emphasized the growing conviction that to facilitate traffic movement by such means is a procedure without end. Much interest is being displayed in the construction of freeways or express highways as a possible solution to the major thoroughfare problem. The extent of this movement naturally gives new concern to those who understand the necessity of providing adequate terminal facilities for high-capacity trafficways leading into congested districts.

The parking problem as a whole, does not appear to be any nearer solution than it was five years ago. Although some palliation has resulted from the transformation of "blighted" districts into parking lots it is obvious that close-in property, being in high-value area, cannot continue in such use. A somewhat more sensible solution of on-street parking is resulting from the extension of the use of parking meters. This may be expected to continue as cities find these meters an important new source of much needed revenue.

Bridge Engineering

Shortridge Hardesty
Waddell & Hardesty, Consulting Engineers
New York, N. Y.

THE YEAR 1936 was marked, from the bridge engineer's viewpoint, by the completion of two monumental structures and several unusual ones, and continued progress along the line of more scientific design. It was further marked by the largest annual expenditure for bridges in history as a result of the federally financed grade separation program.

The largest bridge opened to traffic during the year was the $78,000,000 San Francisco Bay Bridge. Its outstanding characteristics are the twin 2,310-ft. span suspension bridges with an intermediate anchorage designed for unbalanced live-load effects, four piers carried to rock at a maximum depth of 220 ft. below low water by means of a newly-developed type of open-dredging caisson, and one pier carried to a depth of 242 ft. by a false bottom caisson of special design, the double deck tunnel through the rock of Yerba Buena Island, and the 1,400-ft. cantilever span of the East Bay crossing. The suspension-span cables were spun by means of double-grooved spinning wheels, whereby four wires were placed in a cable by a single trip of one wheel.

The second largest bridge completed during 1936 was the $60,000,000 Triborough Bridge in New York City, connecting the boroughs of Manhattan, Queens, and the Bronx. Its distinctive features are a 1,380-ft. suspension span, a 310-ft. vertical-lift span, and a system of ramps on Randall's Island for handling the six main streams of traffic without intersections at grade. Particular attention was given to providing adequate access roads at the three terminals of the bridge. The lift span has a battle-deck floor consisting of asphalt plank on a $\frac{3}{8}$-in. silicon steel plate, and weighs about 2,100 tons. It is of the tower-drive type, with the operating units in the two towers kept in step by electrically synchronized motors.

The year also witnessed the completion of the major construction features of the Golden Gate bridge, which contains the world's longest

span—4,200 ft.—and is to be opened to traffic during 1937. A further advance in cable spinning was made by the use of two sets of triple spinning wheels and double or split tramways. This equipment placed 24 wires in a cable during each round trip of the wheels, which traveled from the anchorage to the center of the main span only. The increase from the single spinning wheels of earlier bridges to double-grooved wheels and to double and triple wheels has been accompanied by the adoption of improved control devices that have permitted wheel speeds to be raised from 450 ft. to 650 ft. per min. As a result, stringing rates of wire have increased from 33 tons per cable in one day for the Manhattan and Philadelphia-Camden bridges to 61 tons on the George Washington Bridge and 271 tons on the Golden Gate structure.

The Homestead Bridge over the Monongahela River near Pittsburgh, now under construction by the Allegheny County Authority, is the first Wichert truss structure to be built, a design characterized by pinned quadrilateral panels over the piers. A light-weight concrete filled I-beam-grid floor, 3½ in. thick, was used on this structure. Preliminary studies showed that the Wichert truss effected a considerable saving as compared with the conventional continuous type, and that it was much less affected by foundation settlement.

The Henry Hudson Parkway in New York City, which was put into service in December, 1936, contains an 800-ft. hingless ribbed arch—the longest hingeless arch and the first important one built in this country since the pioneer Eads Bridge constructed 60 years ago. The ribs are of silicon steel and are 12½ ft. dep. They were erected by progressive cantilevering from the skewbacks and over steel falsework bents, the closure being made at the center by the aid of jacks which introduced the theoretically correct stresses into the ribs. To insure proper closure, the exact distance between skewbacks was measured in the field, and the rib sections manufactured and shop-assembled with unusual care to suit the measured distance.

The Marine Parkway Bridge now under construction in New York City contains a 540-ft. vertical lift span and two flanking fixed spans of the same length. The three spans are floored with open-mesh steel grating, which, by its lightness, effected a large saving in the lift span and a moderate one in the two fixed spans. In both the Marine Parkway and the Triborough lift bridges, particular study was given to the proportioning and architectural treatment of the towers. This increasing attention to appearance and ethetic values has been one of the important tendencies in recent American bridge practice.

The two 230-ft. vertical lift spans of the Pennsylvania R. R. bridge over the Passaic River at Newark, one a single track span and the other a double-track one, are unusual in that they are supported by common towers. The tracks on the double-track span, which carry the Hudson and Manhattan tube trains, are both on grade, one at 0.5 per cent and the other at 2.72 per cent.

The two monumental bridges opened to traffic during the year — San Francisco-Oakland and Triborough—each made contributions to knowledge.

The Golden Gate Bridge cables were spun 24 wires at a time. Continuous truss spans were more widely used.

New lift spans exhibited advance in light decks and appearance.

Rigid frames, cellular girders and trusses built of concrete set new record span lengths.

A riveted steel Vierendeel girder was built in Los Angeles.

Design, theory and procedure were subjected to critical scrutiny.

There was a large volume of moderate-sized and small bridge work under way during the year, much of it with the aid of PWA and other federal money. Continuous spans have featured several of the larger bridges, and rigid frames have been widely used in the smaller structures, many of which have been grade-crossing eliminations. A concrete rigid frame structure in Nebraska contains a 109-ft. main span and two 26½-ft. counter-weighted side spans; while several cellular or hollow-member concrete bridges were built in the state of Washington, one of them being a continuous girder bridge containing a 190-ft. span, and another a rigid-frame structure with a 175-ft. span. Also in Washington, there was built a 170-ft. concrete truss, said to constitute a record length for this country.

In the series of fine bridges along the Oregon Coast Highway which were opened in 1936, concrete arches were adopted whenever practicable, even where pile foundations were used. Several tied arches were employed where through spans were required; and Considère hinges were used in some instances to reduce secondary stresses or to eliminate trouble from possible pier movements.

An important development during the year was the publication by the American Welding Society of its specifications for highway and railway bridges. A small welded double-track single-leaf bascule of 54-ft. span was built on the Florida East Coast Railway at Jupiter, Florida.

Several Vierendeel trusses of 95-ft. span were designed during the year for a Los Angeles County flood control project. Plans were prepared for both welded and riveted construction, bids taken for one bridge on both types, and the riveted design built.

Recent advances in American erection procedure have included the use of tractor cranes and improved trucking equipment, bolt-tightening machines for fitting-up bolts, the application of silicon steel to erection travelers and derricks to reduce their weight, and the replacement of steam power for hoists by electric, diesel and gasoline power. Safety equipment has included hats of hard-pressed material to protect the wearers from falling objects, shoes with soles tough enough to withstand puncture by nails, safety belts, safety nets and special scaffolding.

Papers presented at the Second Congress of the International Association for Bridge and Structural Engineering in Berlin and Munich, Oct. 1-11, 1936, described tendencies in European practice. Continuous girders, Vierendeel trusses and welded bridges are particularly featured. A continuous girder bridge, with plate-girders 18 ft. deep, has spans of 295 ft., 355 ft., and 295 ft.; the girders have a longitudinal field splice at mid-depth. A welded bridge has girders aout 9 ft. deep, the length of the longest span being 208 ft.

The most valuable contribution to design procedure during the year was the symposium on structural applications of steel and light-weight alloys which featured the October meeting of the structural division of the American Society of Civil Engineers in Pittsburgh. The papers covered fully the practical applications of the various materials and were especially valuable in that they pointed out limitations as well as advantages. One paper, on modern stress theories by A. V. Karpov, includes a comprehensive treatment of conventional design procedure and of the fundamental physical properties of the various structural materials now available including not only the usually considered properties like yield point, ultimate strength, elongation and modulus of elasticity, but also the commonly-neglected factors such as endurance limit, fatigue strength, surface conditions and stress-raisers. The question of fatigue, which ordinarily is of little importance but may be the controlling factor under certain stress conditions and for certain materials, merits special study. It is to be noted that the new specifications of the American Welding Society give this factor due consideration.

Soil Mechanics Progress

A. Casagrande
Graduate School of Engineering, Harvard University, Cambridge

WE HAVE gone through a remarkable year in soil mechanics. The new and youthful science saw large advance, but even more noteworthy was the progress in practical application of the science. Flood-control and other projects, particularly the design and construction of dams, led to establishing new large laboratories; research was intensified; a number of engineering schools added soil mechanics to their instruction program or are making arrangements to do so in the near future.

The First International Conference on Soil Mechanics and Foundation Engineering last June reflected this aroused interest in soil mechanics and its applications all over the world, and brought together in the three volumes of its procedings a much-needed summary of information which has not heretofore been available. The Conference also initiated increased activity among engineering societies, foremost of which is the creation of a Soil Mechanics and Foundation Engineering division of the American Society of Civil Engineers.

Pioneer work by Terzaghi

However brief, a review of 1936 properly starts with reference to Prof. Karl Terzaghi's publications, the most valuable and stimulating contributions of the year. In a new book ("Theorie der Setzung von Tonschichten," Vienna, 1936) written in collaboration with Dr. Froehlich, he gives a comprehensive theoretical treatment of the mechanics of consolidation of clay deposits. Continuing his work on the influence of arching on the pressure against retaining walls, timbering of cuts and tunnels (*ENR*, May 14, 1936; Proceedings Soil Mechanics Conference, Vol. I), Prof. Terzaghi succeeded in developing our conceptions to a point where we can understand the many apparently conflicting observations which in the past have caused practicing engineers to look with disdain upon earth pressure theory.

Wholly new light has been thrown on the question of hydrostatic uplift in clays and other materials of very low permeability, such as concrete, by Terzaghi's investigations reported in *Engineering News-Record* (June 18, 1936). In implicit form this paper contains many further discoveries that will be of far-reaching importance to the civil engineer.

Terzaghi's opening address at the Soil Mechanics Conference (Proceedings, Vol. III) represents not only a brilliant exposition of the development of soil mechanics and its application to earthwork and foundation engineering, but also an analysis of the nature of engineering research that should go far toward educating engineers to clear thinking and a healthier and more critical attitude toward theories in general. A thorough study of this address is recommended to every student of soil mechanics.

Stability of earth dams

In several contributions to the Soil Mechanics Conference (Proceedings, Vol. I) Prof. Terzaghi presented important improvements in our theoretical tools for the analysis of slides. The stability of dam foundations found an important treatment in Prof. Glennon Gilboy's contribution to the Proceedings of the Second Congress on Large Dams, held at Washington in September.

The new science of soil mechanics made a powerful impression on engineering practice during the past year, Prof. Casagrande reports. Earth dam stability, foundation settlement, hydrostatic uplift, and improvement of soils by physical, chemical and electrical means, are chief among the subjects concerned in the year's advance.

Every large construction enterprise concerned with earth as a foundation or a construction material relied on soil laboratory guidance.

The international conference at Harvard in June revealed the world-wide extent of practical interest in the new field.

The stability of embankments on clay foundations has also found elaborate theoretical and experimental treatment in the soil mechanics laboratories of the army engineers (results contained in unpublished reports of these laboratories). Particularly the development of the photo-elastic method, using gelatin models, carried out in the Zanesville laboratory of the Muskingum flood control, has been very productive and stimulating (Knappen and Philippe, *ENR*, 1936).

Embankments of fine-grained cohesionless soils have been analyzed theoretically and experimentally as to their stability by the author (*Journal* Boston Soc. Civil Eng., Jan. 1936). Through a new concept, *critical porosity*, it was possible to offer a method for approaching such problems scientifically. However, it seems that much research remains to be done before these new ideas can be applied practically. In connection with the studies, model tests were used to demonstrate the lack of stability of saturated deposits of sand in a state above the critical porosity.

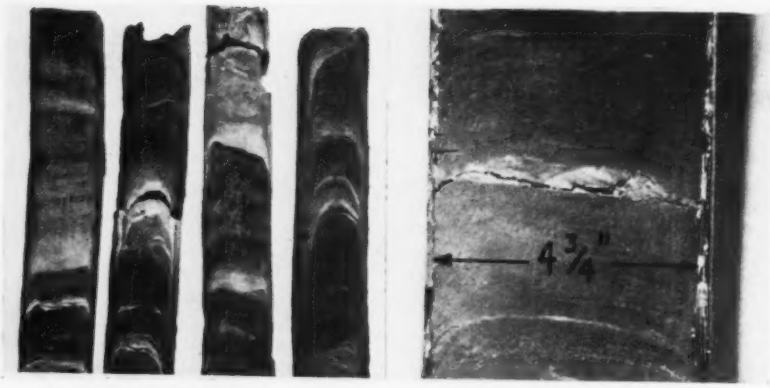
At this point a warning must be issued against attempts at deriving from model tests quantitative data on the degree of stability of large embankments or on the amount of subsidence which will take place due to failure of dam foundations. In a model the mass forces are too greatly reduced, so that in the prototype the movement during failure will continue beyond the range observed in model tests. Thus such model tests may give rise to a false sense of security—unless they are used only as a guide in the interpretation of failures of fills and their foundations.

In the last analysis further progress in this question is essentially dependent on comprehensive studies of actual slides, utilizing in the analysis the latest improvements in our theoretical tools which have been made by Fellenius, Krey, Terzaghi and others. Recent examples of analyses of slides are contained in the proceedings of the soil mechanics conference. It is noteworthy that such observations continue to bear out the great inherent value of Petterson's discovery, which he made two decades ago, that slides in soft soils occur along cylindrical sliding surfaces.

Settlement of buildings on clay

Marked progress has been made in analysing the relationship between the consolidation characteristics of soil samples as determined in the laboratory and the actual settlements of structures. In this connection the need for special attention to the "preconsolidation load" is becoming more and more apparent, and methods for its determination have been materially improved. This work has also led to a criterion for the degree of disturbance of a specimen due to the sampling operations, and to methods of compensating for it, at least partly, in the interpretation of the test results.

Recent (unpublished) investigations by P. C. Rutledge, of Harvard University, have led to a new method which permits the determination of the compressibility of clay strata (so far developed only for the clays of Boston, Detroit and Chicago) by means of determinations of the Atterberg limits and the natural water content of the small samples which are obtained in ordinary exploratory borings. This method also makes it possible to take into account the con-



ALL SOIL SAMPLES are disturbed to some extent, but the large (4¾-in.) sample obtained with large spoon is less disturbed than the small (1⅛-in.) samples made by driving thin steel tubes in 2-in. casing.

tinual variations in compressibility which are found throughout every natural clay deposit.

The first fundamental requirement for any foundation investigation is thorough exploration of the underlying soil strata and the obtaining of undisturbed samples. As to sampling, we know today that only large samples, taken with care directly by hand, can be considered undistured. All samples from drill holes are disturbed to some degree, frequently so as to make test results very misleading.

Various investigations during the past year have led to the following conclusions regarding the chief sources of disturbance: (1) Samples are too long in relation to their diameter, or all dimensions are too small; (2) samples obtained by dynamic forces instead of static pressure are often disturbed; (3) samples are disturbed in the process of removal from the sampling spoon, as when blown out with compressed air, and most soils expand within the spoon, resulting in side friction over their entire circumference; (4) sampling of disturbed material extruded into a hole not kept open by casing, or of material squeezed up into the casing by large unbalanced pressure, results in completely unreliable information.

To overcome these difficulties it was found necessary, for almost all conditions, to keep the casing close behind the sampling operation and to proceed with the boring and sampling operations without interruption (24-hr. operation). The clay removed between the taking of samples should preferably not be removed by washing but by the same method as the sampling; for this purpose, to permit rapid progress, much longer cylinders may be used than the sampling spoons from which the undisturbed samples are recovered.

Improving the properties of soils

Promising new developments and improvements in methods of treating soils to improve their properties for engineering purposes have appeared during the past year. Thorough discussions are contained in the proceedings of the soil mechanics conference and in a number of papers presented before the Highway Research Board in December. It seems that we are only at the beginning of a period in which the treatment of soils by physical, chemical and electrical means will lead to important innovations in earthwork, foundation and highway engineering.

Standardization

An almost universal desire for standardization has become articulate in the field of soil mechanics. Such tendencies are not difficult to understand, since they are an outgrowth of an aroused interest in soil mechanics and of the attempts of engineers to apply the published experience of others to their own problems. Admittedly, some terms used in the literature of soil mechanics show an amazing variety in meanings, and standardization of the most important terms is highly desirable and should be attempted. The question of standardization of the mathematical symbols used in soil mechanics will probably turn out to be a difficult task and should be preceded by a comprehensive compilation of present usage. Finally, attempts at standardization of soil tests are entirely premature in the opinion of the writer, except for a few minor tests.

Conclusion

While it is not possible in this brief review even to mention all of the year's worthwhile contributions to soil mechanics, it should be emphasized that encouraging progress has been made in observations on full-size structures. These observations are perhaps not always as accurate and complete as might be desired, but it is a favorable sign that the realization of the importance of such observations is steadily growing.

In the publications of the past year one can also detect an encouraging abstinence from excessive generalization, in contrast to the soil mechanics literature of previous years, in which unwarranted generalization caused unfavorable reactions toward the new science on the part of practicing engineers. We may look forward with keen anticipation to the developments in soil mechanics in coming years. Many of them are certain to have their origin in observation of the behavior of structures by practicing engineers combined with the correlation of such data with soil study.

Materials Improvements

H. L. Whittemore
U. S. Bureau of Standards, Washington, D. C.

TO SINGLE OUT the increment of advance in the field of materials that belongs to any given 12-month period, such as the year 1936, one must necessarily be somewhat arbitrary. Trends, however, can be recognized and some achievements are definite.

As to general trends, it would seem that we are now or soon will be faced with the necessity of using less material for our designs, thus placing a premium on technical skill and ingenuity and requiring more reliable data on the properties of materials. Each year more manufacturers recognize this fact by instituting new research to provide necessary information about chemical composition, methods of manufacture, heat treatment, microstructure, specific weight, modulus of elasticity, strength, ductility, resistance to fatigue, impact, corrosion, etc.

Turning to consideration of some of the specific materials, wood in 1936 continued to improve its standing in the engineering field. Grading, standard working stresses for structural timber, better practices in the preservative treatment of wood, more efficient timber joints, the introduction of laminated construction and an increasing use of structural plywood are some of the factors which have brought this about. Plywood, for example, has grown by leaps and bounds.

In 1935 the industry produced 480 million sq.ft., while the quantity manufactured in 1936 was 700 million sq.ft. or an increase of 40 per cent. There is every indication that the production of Douglas fir plywood in 1937 will exceed that of all previous years.

The development of highly waterproof phenolic resin glues has extended its field of usefulness to many phases of outdoor work. Architects and builders have not been slow to appreciate the possibilities of plywood for housing. In the Northwest several concerns have been using glued-up plywood walls units with marked success, and one of the large steel-house companies is building its houses with plywood walls. Plywood has also found application in floors and partitions of railroad coaches, baggage and mail cars.

Glued laminated wood arches were used in a number of buildings in 1936. The use of metal dowel connectors for timber framing continued to grow.

Low-alloy steels

More new low-alloy proprietary steels were introduced during the year. Some fifteen such steels are available, dividing generally into two main classes—chrome-copper and nickel-copper. Characterized by a high ratio of yield-point to ultimate strength, they permit lighter construction and thus compete with the more costly stainless steels and aluminum alloys. The latter have enjoyed increased acceptance on such construction equipment as buckets and dragline booms. New applications are being found for nickel-clad steel. Welding qualities of steels continued to be emphasized. A revised specification for structural nickel steel was issued by the A.S.T.M.

Almost every large steel producer has installed automatically controlled continuous rolling mills for the production of wide strip or sheet in thin gages. New markets are being sought for sheet steel in the construction of buildings. Much study is being given to the engineering problems involved.

Ferrous castings have recently come into use for machinery parts such as crankshafts, pistons, brake drums, etc., and for other parts formerly forged from steel. Many of these castings are modified cast irons. The high strength and ductility are obtained by alloying elements, improved melting and casting techniques and by heat treatment.

Silicon bronzes having high strength, ease of fabrication, excellent resistance to corrosion and low cost have assumed a position of real importance in the heavy non-ferrous alloy field. The advantages have been definitely established of using copper-beryllium alloys for special applications where a high-strength, corrosion-resistant, non-ferrous material is required.

The application of protective coatings by electro-plating has been progressing rapidly. Electrolytic tin-plate and electrolytic zinc-coated wire are on the market. Experiments on electrolytic zinc plating of steel sheets indicate that this product also will soon be commercially available. There has been a tremendous increase in the use of thin-wall seamless drawn copper tubing for domestic plumbing and industrial piping.

Developments in the field of materials were significant if not spectacular.

Wood continued to improve its standing as an engineering material.

New low alloy steels of chrome copper and nickel-copper type were announced under proprietary names.

Weld metal quality was further improved. Special cements, particularly for corrosive service, extended their field of application.

Improvements were marked in unit masonry of clay and concrete types. Insulation materials and synthetic plastics attracted more attention.

Recently great improvements have been made in filler metal for welds. Not only has the ductility of the weld metal been increased by using heavily coated electrodes, but filler metals now available produce welds that equal or exceed the base metal in other physical properties.

During the past year research has resulted in a broadening of our knowledge of the constitution of portland cement, of methods of controlling manufacturing processes and of the use of cement in concrete. Committee C-1 of the A.S.T.M. has continued its deliberations on specifications for cements of different types, each suited for a particular purpose. An approved new definition of portland cement permits the addition of small amounts of admixtures other than gypsum, a change sought by those who feel that the old definition was complicating if not thwarting improvement. Federal specifications for four types of portland cement—normal portland, high early strength, moderate heat and sulphate resistant—have been, promulgated. High silica cements for seawater and other corrosive service were used more widely.

The use of precise methods for proportioning concrete has been extended. More and more, aggregates from several sources are being combined to give a distribution of particle size complying with a rigid specification. The use of the vibration method for placing concrete has been extended. Laboratory studies have been directed toward determining the types of equipment best suited for compacting concrete as well as the effect of vibration on the properties of plain and reinforced concrete.

In the field of unit masonry, the A.S.T.M. has revised its tentative specifications for clay building brick to include, for the first time, a description of the different conditions to which brick masonry is exposed and specification requirements for bricks suitable for each condition. Use of this specification should result in greater durability of brick masonry. The committee also has prepared a new tentative specification for glazed building units of clay, the first nationally recognized specification in this country for these products. De-aired brick is being studied both in service and in the laboratory.

Concrete curing

Investigations of the effect of high-pressure steam curing on the properties of concrete units point the way to a method of manufacturing which will minimize, if not entirely eliminate, troubles in service caused by shrinkage. New standards both for structural clay tile and for hollow masonry concrete building units were published by the A.S.T.M. during the past year. A specification for hydraulic hydrated lime, a material used in Europe for many years and now available commercially in this country, was issued by the A.S.T.M.

The public has become more insulation-conscious during the past year. Much attention is being given by industrial organizations to making heat insulation from their waste products. Every house built for sale has to include insulation to be considered modern. Sound insulation also is assuming considerable importance for residential building; tenants are leaving apartments if they are disturbed by their neighbors. The commercially available sound insulation materials are quite satisfactory, the principal difficulty being in the design of the building for efficient and economical installation of the insulation.

Although organic plastics are not employed as structural members in building construction, the use of these materials in the form of laminated paper bonded with synthetic resin for interior trim is developing rapidly, and several new companies have been organized recently to meet the growing demand. Another recent development of interest is a thermoplastic synthetic resin that has the appearance of ordinary glass but only one-half its weight, and much greater resistance to shattering. Also it is readily formed into curved shapes by moderate heat.

Status of Major Projects

Water Supply Projects

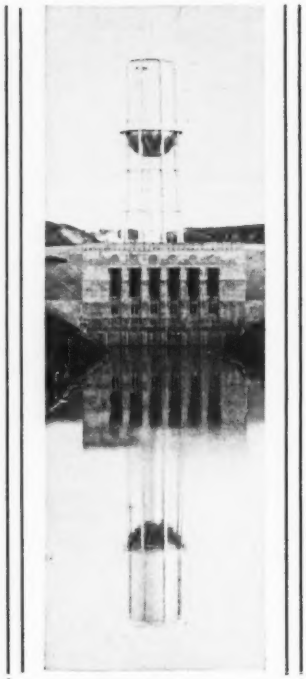
✦ **Parker Dam**—Before the end of the year the Colorado River had been diverted through two tunnels driven around the site of Parker Dam at the intake of the Colorado River aqueduct and excavation was proceeding in the 2,000 ft. length of unwatered riverbed.

✦ **Colorado River Aqueduct**—All tunnel driving on the 242-mile Colorado River aqueduct except that for the San Jacinto tunnel has been completed and much of the concrete lining has been placed. San Jacinto tunnel continues to be the "neck of the bottle" but an intermediate shaft and the use of pioneer bores renew prospect for completion not far behind schedule. The earthfill dam and dike that will form Cajalco reservoir are well under way as are tunnels and large size pipe lines on 60 miles of the 150-mile distribution system.

✦ **Mono Basin**—Good progress was made during 1936 on Mono Craters tunnel, 11.3 miles long, the time limiting element in obtaining an addition to the Los Angeles water supply system from a point about 100 miles beyond the existing Owens Valley aqueduct. The tunnel is expected to be ready for service in the fall of 1938. A major difficulty has been sinking the 900-ft. Shaft 1. This was down 763 ft. by the middle of the year when water and quicksand were encountered which involved long delays. Two earthfill dams (Great Lake and Long Valley) are well under way.

✦ **Colorado Springs**—Last year saw practical completion (99.54 per cent) of the $1,710,000 project for increasing the water supply of Colorado Springs by two steel-faced earth dams on the North Slope of Pikes Peak. The fill, largely disintegrated granite, grossed 600,000 cu.yd. and the steel plates 1,732 tons. Nearly 10 mi. of 20 and 24-in. steel pipe line connects the dams with the city's distribution system.

✦ **Transmountain Water for Denver**—Completion is in sight this year of Denver's Moffat Tunnel Extension Project whereby water from the West Slope will be diverted to the South Platte, the supply on which the city has heretofore depended. Collection systems were essentially completed last year. The enlarged Moffat water tunnel was finished in November as were the canals, diversion dam and conduits bringing water to the Ralston Dam site. The Ralston Dam to impound water for the winter season is 33 per cent complete and will start storing water in May. The 9-mi. 42-in. concrete conduit from the dam to the West Side filter plant is 30 per cent complete and work on the 63-in. steel line connecting the filters to the city mains has just started. The filter plant is 85 per cent complete.



POWER PLANT of the Sutherland project, first of Nebraska's group of public power developments.

✦ **Little Rock**—A new mountain water supply for Little Rock, Ark., to replace the highly polluted Arkansas River water is well under way. Six miles of the 32½ mi. 39-in. gravity concrete line from the 14-billion gal. reservoir has been laid. Work on the compacted earth fill dam has been suspended for the winter but concrete work on the diversion conduit and spillway excavation is progressing. The total estimated cost of the project is $3,100,000.

✦ **Revamping Cincinnati Filter Plant**—Rehabilitation of the 30-year old Cincinnati filter plant at a cost of $3,200,000 is about one-half done. A $943,000 contract for new chemical building, coagulation basins including clarifiers and coagulating equipment is 60 per cent completed. Reconstruction of the head house and 26 old filters and addition of 14 new filters, a $1,374,000 contract, is 40 per cent complete.

✦ **Milwaukee Filter Plant**—Contracts in excess of $3,201,000 have been let and are 80 per cent completed on the 200-m.g.d. $4,875,000 Milwaukee water purification plant. Contracts awarded in 1936 cover filter superstructure, heating and plumbing systems, front building substructures, pumps and pump piping, filter equipment, conduits and surge shaft, meters and valves aggregate $1,547,350. Bids were received Dec. 21 for short shafts and tunnel changes and Jan. 12 for pneumatic conveying equipment.

✦ **Springfield (Ill.) Filters**—The $507,000 water softening plant, last unit of the Lake Springfield $6,000,000 project, was placed in operation late in the year.

✦ **Chicago Water Works**—Outstanding accomplishment of the Chicago Water Department during 1936 was the placing in operation of the $2,327,000, 300-m.g.d. electrically operated Cermak pumping station. At Central Park pumping station a new 80-m.g.d. unit was installed and a similar installation for the Springfield station is under way. The 69-year old Two-Mile crib, the oldest of Chicago's cribs, was taken out of service and razed. On filtration, small progress has been made. However, a permit from the Chicago Park District has been granted to build the South Side plant on the lake shore. The state has held up the permit and the War Department awaits action by the state. A PWA grant application rests in Washington.

✦ **New York's Delaware Project**—Bids were opened shortly after the first of this year for the sinking of the first 13 of 30 shafts along the route of the 85 mile pressure tunnel aqueduct that will bring 540 m.g.d. of water to New York City from three reservoirs to be built on tributaries to the Upper Delaware and Hudson rivers. The total project is estimated to cost $273,000,000.

✦ **Baltimore Water Tunnel**—Bids have been received and construction will soon be started on a 12-ft. diameter pressure tunnel running from Gunpowder Falls to the Montebello filter plant, a distance of 6½ miles. This structure will supplement an existing tunnel and reduce pumping charges. The total cost is estimated at $5,300,000, and it will require three years for completion.

✦ **Boston Water Supply** — The last major link in the Quabbin Reservoir development for Boston's new water supply was started last fall with award of contract for Quabbin Dam, a 2,500,000-cu. yd. hydraulic fill dam on Swift River. Stripping has been under way since start of work, and hydraulic filling will commence in May. Quabbin

CUT THROUGH THE SANDS of the desert, the All-American Canal will carry Colorado River water from Imperial Dam 80 miles to the irrigation system of the Imperial Valley. The canal is 260 ft. wide at this point.

Dike, another hydraulic fill of nearly equal proportions, is about complete. The two structures create the new reservoir. Most of the highway relocation has been done; some work remains in removing of towns and villages in the reservoir area.

Sewage Treatment

✦ **White's Point Sewer Outfall**—Practically the entire inshore half of the mile-long ocean outfall sewer under construction by the Los Angeles County sanitation districts at White's Point, was completed before the end of the year.

✦ **Denver Sewage Treatment**—See caption of picture on p. 186.

✦ **Twin Cities Sewage Works**—The $15,500,000 chemical treatment sewage disposal and intercepter project of the Minneapolis-Saint Paul Sanitary District will be completed late this year. Of the 50,000-ft. intercepter system only 2,500 ft. of tunnel remains to be driven. Screens and grit chambers and administration building have been completed. The mixing and flocculating tanks, rectangular settling tanks and magnetite filters are under construction. The vacuum filters and incinerators are the only major contracts yet to be awarded.

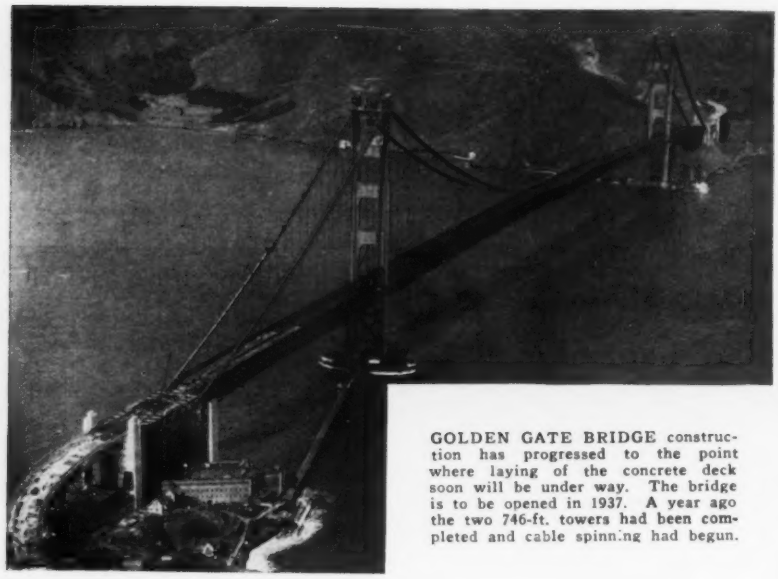
✦ **Sanitary District of Chicago**—A record high of $17,035,000 in contracts awarded in 1936 was made by the Sanitary District of Chicago in prosecuting its treatment program. Contractors earned $15,496,000 and uncompleted 1935 contracts on Jan. 1, 1936 amounted to $9,626,000 leaving a balance of $11,165,000 uncompleted with which to start this year. Works estimated to cost $7,632,000 are to be contracted for soon. All of the $58,630,000 program financed by PWA is expected to be complete early next year. Outstanding as the largest yet built is the 400-m.g.d. Southwest activated sludge plant ultimately to be expanded to treat 1,000 m.g.d. Upon completion of the present program 97 per cent of the sewage and all of the industrial wastes within the 422-sq.mi. area of the district, equivalent to a total population of 6,265,000 will be treated. Work is well started on the $2,052,000 contract for the Chicago River controlling works that will prevent reversals of the river following heavy rainfalls and lake seiches.

BUCHANAN DAM on the Colorado River of Texas, begun several years ago is a private project and now being completed as a public undertaking. The arches have a span of 70 ft.

✦ **Atlanta Sewers and Sewage Disposal**—A comprehensive program is under way involving the construction of 60 miles of sewers (estimated cost $4,000,000) and six treatment plants. These plants vary in capacity from 0.2 to 40 m.g.d. and their total cost will be almost $2,000,000. The Intrenchment Creek job, a remodeling of an existing plant, is about 65 per cent completed; construction has just been started on the Clayton, South River, and Utoy plants. The sewer program is 40 per cent completed.

✦ **Buffalo Sewers and Sewage Disposal**—The $13,500,000 sewer and disposal plant project started a year ago last December is now 20 per cent completed; about 70 per cent of the work is under contract and the entire job is scheduled for completion in 1938. Storm relief and intercepting sewers will cost $9,500,000.

✦ **Cleveland Sewage Treatment**—Considerable progress has been made toward completion of new facilities and in the improvement of existing treatment plants. Construction on the new 123 m.g.d. Easterly activated-sludge plant is on schedule and it will be placed in service in 1937. At the Westerly plant vacuum filters and incinerators are now being installed for sludge disposal. Work under way at the Southerly works includes an aeration unit between the Imhoff tanks



GOLDEN GATE BRIDGE construction has progressed to the point where laying of the concrete deck soon will be under way. The bridge is to be opened in 1937. A year ago the two 746-ft. towers had been completed and cable spinning had begun.

and sprinkling filters, and the replacement of existing final settling tanks with magnetite filters; filter equipment and incinerators are also being installed to handle sludge from both the Easterly and Southerly plants.

✦ **Washington Sewage Disposal**—A 130 m.g.d partial treament and separate sludge digestion plant is practically completed and will be placed in operation within the next few months.

✦ **Niagara Falls Sewage Treatment**—The 90 m.g.d partial treatment plant employing fine screen with anthracite coal mat filters, centrifugal sludge dewatering machines and an incinerator, is about 20 per cent completed. The 5½ mile sewerage extension program costing $800,000 is about 90 per cent finished. The entire project is estimated to cost $2,050,000.

✦ **New York City Sewage Disposal**—About one-third of the facilities needed to provide treatment for the present sewage flow (38 separate plants are contemplated) are now either being designed, under construction or in operation. A 65 m.g.d. activated sludge plant for the Jamaica Bay area is in the design stage. The 180 m.g.d. Ward's Island activated sludge plant, started in 1931 but abandoned for two years because of lack of funds, will be completed at the end of 1937. Construction has been started on the 40 m.g.d. Tallman's Island activated sludge plant which is located near the site of the 1939 World's Fair site on Flushing Bay. The Coney Island 35 m.g.d. part-time chemical precipitation plant, functioning as a plain sedimentation unit until chemical equipment was installed last summer, is now in full operation.

AT GRAND COULEE DAM concrete work on the West cofferdam was brought up during the year to the point where the cofferdam could be taken out and the river diverted through openings left in the dam. Work is here shown in progress in the East cofferdam on the far side of the river. Concreting has been stopped for the winter.

Flood Control

✦ **Los Angeles County Flood Control**—For a considerable part of the year more than 11,500 men, almost exclusively from relief rolls, were employed in Los Angeles County on flood control work, constructing flood channels, bank protection and debris basins. For progress on San Gabriel Dam No. 1, see opposite page.

✦ **Conchas Dam** — Contract for the main portion of the $12,500,000 gravity type Conchas dam, 220-ft. high on the South Canadian River, New Mexico, to store 600,000 acre-ft. for flood control and water supply was let Sept. 10 with completion date set for June 30, 1939. The contractor is now engaged in the construction of the first cofferdam, foundation excavation and erection of construction plant, including an aggregate plant 2 mi. downstream and concrete batching plant at the damsite.

✦ **Marshall Ford Dam**—Contract for the Marshall Ford power and flood control gravity-type dam, 15 mi. upstream on the Colorado River from Austin, Tex., was let in December last. Only the low dam, 190 ft. high, is included in this contract of $5,781,000. Ultimately the 600,000 acre-ft. capacity will be increased to 3,000,000 acre-ft. by raising the dam to its full designed height of 265 ft.

✦ **Buchanan and Inks Dams**—Work has been resumed on the multiple-arch section of Hamilton Dam in Texas (now called Buchanan Dam) under the administration of the Lower Colorado River Authority, largely on a force account basis. Clearing and a rolled fill section have been contracted for. Most of the land including several town sites ultimately to be flooded has been acquired. Work on the Roy B. Inks gravity dam, 3 mi. downstream, which is an integral part of the project, was started by a contractor last summer. It is 1,700 ft. long and 66 ft. high.

✦ **Rio Grande Rectification** — This project which will eliminate flood hazards and stabilize the international boundary between the United States and Mexico through El Paso-Juarez Valley on the Rio Grande was continued during 1936 by the International Boundary Commission. On Jan. 1, 1937, there had been completed 105 miles of levee and 57 miles of river channel, involving about 9,600,000 cu. yd. of earthwork. The project is about 68 per cent complete. When completed the river length between El Paso and Quitman Canyon will have been reduced from 155 to 86 miles.

✦ **Lower Rio Grande Flood Control**—Work on this project was continued by the United States Section of the International Boundary Commission, an appropriation of $1,600,000 having been

made available pursuant to Congressional authorization. When completed the project will include about 90 miles of levee along the United States side of the Rio Grande, 158 miles of floodway, 195 miles of floodway levee, and numerous structures including those at the floodway entrances to control the amount of water taken from the river. Mexico is constructing similar works on the south side of the river.

✦ **Rio Grande Canalization** — The American Dam and Canal feature of the project near El Paso, Texas, is being constructed by the United States Section of the International Boundary Commission under an initial appropriation of $1,000,000. The project includes a low concrete diversion dam, equipped with radial gates across the Rio Grande and a concrete-lined canal two miles in length. The works are designed to furnish control of all irrigation waters released from the Elephant Buttee Dam so that the delivery of the water allotted to Mexico under the treaty of 1906 may be definitely accomplished and the remainder of such releases directed to American lands. Contract for the major part of the work was let on Dec. 16, 1936.

✦ **Caballo Dam**—Designed for flood control and irrigation, the $2,500,000 compacted earth fill, Caballo Dam, 25 mi. below Elephant Butte Dam, New Mexico, is well started. Excavation for the 33,000 sec.-ft. concrete lined spillway is two-thirds completed. Concrete lining is being placed in the 13½-ft. diversion tunnel. The river is to be diverted March 1. The embankment foundation stripping is one-third done. Completion date of the project is two years off.

✦ **Winooski River Flood Control**—During the season of 1936, work on the Waterbury dam was continued, and 40 per cent of the earth fill was placed in the structure. Work on the gate tower and spillway is now in progress. Operations are scheduled for completion by December, 1937.

Waterways

✦ **Florida Canal**—Work on the ship canal across northern Florida, begun in 1935, was discontinued early in 1936 after Congress declined to vote additional funds for the work. About $6,000,000 has been spent to date. Late in November a special board of army engineer officers set up to study the project reported to the Chief of Engineers in favor of building the canal at a cost estimated at $157,585,000, exclusive of land. This report was made the subject of hearings before the Board of Engineers for Rivers and Harbors in December but that board has not yet made public its findings.

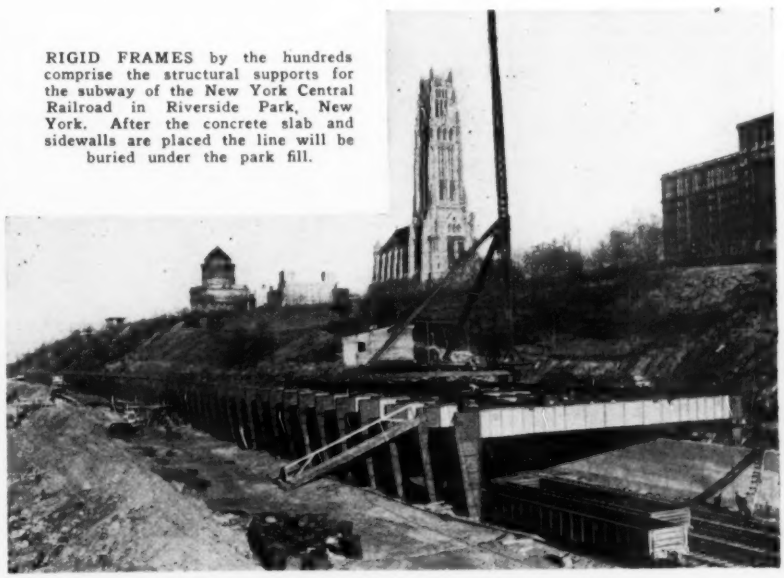
✦ **Upper Mississippi Canalization**—Work is completed on most of the locks and on a number of the dams in the group of 26 locks and dams involved in the canalization of the 693-mile length of the Upper Mississippi River between St. Louis and St. Paul. Of the locks, 19 are complete, 4 are nearly complete, 2 are well under way, and one has just been started. Of the dams, those at Keokuk, Hastings, and St. Paul were built before the present program was started. The Rock Island dam was built in 1933, dams at Alma and Fountain City were completed in 1935, dams at Winona, Trempeleau and Canton were finished in 1936. Seven others are scheduled for completion in 1937 and four in 1938. The entire program, costing $150,000,000, is scheduled for completion in 1939.

SAN GABRIEL DAM NO. 1, a great rock-fill dam in the San Gabriel Canyon back of Los Angeles, is rapidly rising above the valley floor. Some 5,500,000 cu. yd. of material was added to the structure during 1936 and by the end of the year the dam had reached an average height of 200 ft. above foundation. The total height is to be 376 ft. and the total yardage 10,641,000 cu. yd.

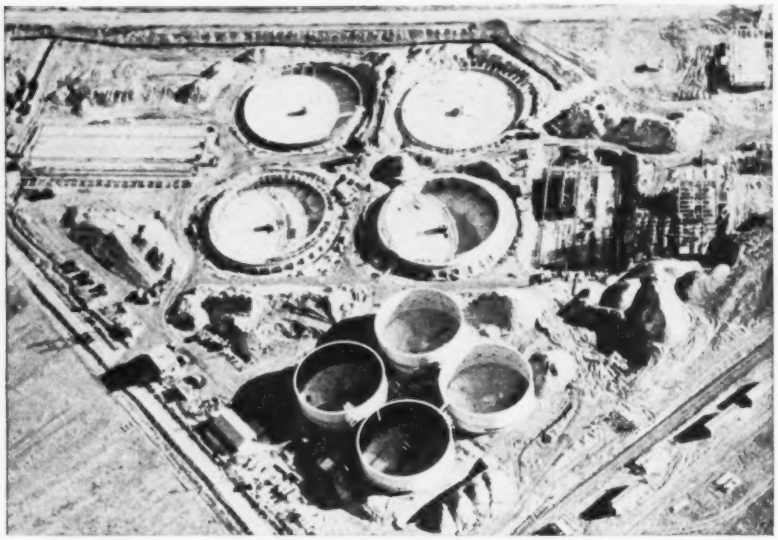
✦ **Chesapeake and Delaware Canal**—Conversion of the Chesapeake and Delaware canal into a sea-level channel with a minimum width of 250 ft. and a depth of 27 ft. is about 30 per cent complete. One lock has been removed and most of the bridge alteration work is well along toward completion. The cost is estimated at $14,000,000.

✦ **Cape Cod Canal**—The project for enlarging the Cape Cod Canal to a width of 540 ft. in the overland section and a width of 500 ft. in the straight approach section in Buzzard's Bay, to depth of 32 ft. at mean low water, was continued during the past year. At the close of the last fiscal year, the entire project was about 40 per cent completed.

✦ **The Tennessee River Development**—The Tennessee Valley Authority has now under construction or has completed six dams. Two of these, Norris and Hiwassee, are tributary storage dams while the other four, Pickwick Landing, Wheeler, Guntersville, and Chickamauga, are located on the main river. With the completion of these projects and certain comparatively minor intermediate adjustments, a nine-foot channel will be available from Pickwick Landing Dam, at Mile 206.7, to 59 miles above Chattanooga or Mile 530. Norris Dam was finished during the year and two generators, capacity 56,000 kv-a each, have been in operation in recent months. Wheeler Dam on the main river above Wilson



RIGID FRAMES by the hundreds comprise the structural supports for the subway of the New York Central Railroad in Riverside Park, New York. After the concrete slab and sidewalls are placed the line will be buried under the park fill.



DENVER'S SEWAGE DISPOSAL PLANT under construction on the north bank of the South Platte River. In the right foreground are the four 85-ft. diameter sludge digestion units; in back of these are the bases of the 140-ft. diameter clarifier tanks, adjoining which is the rectangular magnetite filter structure. At the right are the uncompleted aeration basins, the chemical and administration buildings of this 54 m.g.d. plant.

Dam was practically finished during the year, and its pool filled in December. One of its two 36,000-kv-a generators being initially installed has been in operation. Pickwick Landing Dam, below Wilson Dam, is entering its third year of construction. The navigation lock is now practcally complete and the cellular cofferdam removed. The cofferdam for the second construction has been completed and concreting of the intake and a portion of the spillway is well advanced. The embankment work for the earth dams is about three-fourths complete. Guntersville Dam, the next above Wheeler, was started late in 1935. About three-fourths of the lock concrete has been placed, while the earth embankments are roughly one-third complete. Chickamauga Dam, immediately above Chattanooga, was started early in 1936. Despite foundation difficulties, work has proceeded rapidly and the lock concrete is now more than one-third complete. Considerable work has been done toward sealing the foundations under the earth dam sections.

✦ **Fort Peck Dam**—The 100,000,000-cu. yd. hydraulic fill dam at Fort Peck, on the Missouri River in northeastern Montana, is now half done. Last year 28,000,000 cu. yd. were pumped into the main dam and into the long dike to the west, the latter structure being completed. The four diversion tunnels are complete except for placing of inner concrete lining on Tunnels No. 2, 3 and 4 at their lower ends, where additional concrete is required to reduce the bores to the revised diameter of 24½ ft. Fabrication and placement of the steel plate lining in the lower half of Tunnel No. 1, for future penstock, is under way. The spillway gate structure is about ready for installation of the gates, and more than half of the spillway cut has been paved. Work is under way on the deep cutoff wall at the lower end of the paved spillway section. The government is opening a quarry near Malta for supply of riprap and blanket stone.

✦ **Gallipolis Dam**—Both locks at the Gallipolis Dam project on the Ohio river near Gallipolis, Ohio, are complete and in operation. The contractor on the dam is now working in the third and last cofferdam, though he has been flooded out since Jan. 1. Five of the 125-ft. roller gates, the largest ever installed in this country, are in place, with three more to be set. Gallipolis Dam controls navigation on the lower stretch of the Kanawha as well as that on the Ohio. Winfield Dam, at headwaters of the Gallipolis pool on the Kanawha, is half completed; the twin locks are in service. Winfield Dam will complete the 9-ft. canalization of the Kanawha River.

Power Development

✦ **Skagit Power Project**—Two 83,300 hp. reaction turbines to operate under a 389-ft. head were installed by the city of Seattle during 1936 in the Diablo hydro-electric plant on the Skagit River. The ultimate capacity of this plant will be 320,000 hp. Preliminary work also was begun by the city on the Ruby plant, next upstream from Diablo to cost $7,185,000. A 110-kv. transmission line between the Gorge and Diablo plants was built during the year and an additional transmission line to Seattle is planned.

✦ **Bonneville Dam**—The north half of the dam site for the Bonneville power and navigation project on the Columbia River (40 miles from Portland, Ore.) was unwatered during the year and an estimated total of 250,000 cu. yd. of puzzolanic concrete was added in the main spillway dam. Removal of the north cofferdam is planned for early in 1937. Much work has been done on navigation lock and fishway systems and machinery was partly installed in the power house.

✦ **Passamaquoddy Power**—Operations on the tidal power project in Cobscook Bay (adjoining Passamaquoddy Bay) in Maine were put on a reduced scale early in the year after Congress failed to provide funds to continue the work. The number of men employed was cut from around 5,000 to less than 300, these being engaged chiefly in quarrying rock to complete the Pleasant Point and Carlow Island dams. These low dams were built by filling from trestles of the Maine Central R. R. and had to be completed and faced with granite under the government's agreement with the railroad company.

Irrigation and Power

✦ **Boulder Dam**—Completion of penstock and control equipment and the installation of machinery in the power houses has constituted the major activity during the year at Boulder Dam. The transmission line to Los Angeles (286 miles) has been completed and a pageant of light held in that city on Oct. 9 celebrated delivery of the first Boulder power. As a construction project Boulder Dam is complete.

✦ **Grand Coulee Dam**—During the year concrete in the west cofferdam at Grand Coulee Dam was brought up to a height above the level of flood water and on Nov. 7 water was diverted over concrete in the west portion of the dam. Placement of cribs for the east cofferdam then began and final closure was made Dec. 15. Excavation at the east abutment was under way before the end of the year. Total concrete placed as of Dec. 31, 1936, was 1,873,000 cu. yd. (including 58,000 cu. yd. on the east side), total excavation 15,300,000 cu. yd., total expenditure $37,690,000.

✦ **North Loup River Project**—Main line canals of the $1,400,000 North Loup Public Power and Irrigation Project, centered at Ord, Neb., totalling 72 mi. are under contract and other contracts for structures and laterals will be awarded within a month. Completion this year is expected.

✦ **Tri-County Project**—This project of the Central Nebraska Public Power and Irrigation District will consist of the Keystone Dam on the North Platte River, the supply canal which will take water diverted just below the town of North Platte to the Jeffrey and Johnson power plants, and the Smithfield, Phelps County and Adams County irrigation systems, to irrigate 285,000 acres within the Platte River watershed. Of these works, only the main Phelps County and Adams County irrigation canals have been completed, totaling about 94 miles of canal and involving about 9,000,000 cu.yd. of excavation. Control structures on these canals have not yet been commenced, but a majority of bridges are completed. Construction of the balance of

the work, except for some preparation of dam sites, has been held up by litigation, but surveys have been completed and design work is well advanced. The Keystone dam, to impound 2,000,000 acre-ft. of water, will be of earth, 160 ft. high, about 2 miles long and requiring about 28,000,000 cu. yd. of fill. The supply canal is about 75 miles long and estimated earthwork is about 26,000,000 cu. yd. The two power drops, with a total gross head of 378 ft., will have an installed capacity of 54,000 kw. The cost is estimated at $32,000,000.

✦ **Sutherland Project** — The Sutherland (Neb.) project of the Platte Valley Public Power and Irrigation District, a combined power and irrigation development, delivered to irrigators 30,000 acre-ft. of water during last summer's drouth, and began delivery of electric power to the City of North Platte in December. The project includes a diversion dam across the North Platte River, 35 miles of canal to the Sutherland Reservoir, which is formed by 6 miles of earth dikes. 20 additional miles of canal to the regulating reservoir above the power house, penstocks, a surge tank and a power house containing 25,000 kw. in generating equipment; also 300 miles of transmission lines. The project is complete, with the exception of some necessary additional canal lining and drainage works. Total excavation amounted to 13,000,000 cu. yd.; earth dams and dikes 4,100,000 cu. yd.; concrete structures 150,000 cu. yd.; Gunite canal lining 1,200,000 sq. ft.

✦ **Columbus Projects**—The Columbus-Genoa project of the Loup River Public Power District in Nebraska includes a diversion dam and desilting works on the Loup River, 15 miles of canal leading to the Monroe power house where 7,800 kw. is to be developed, 17 additional miles of canal and a regulating reservoir above the Columbus power house where 39,900 kw. is to be developed and a 7-mile long tailrace to the Platte River. Construction is 90 per cent complete, canal seasoning is in progress and generation of electricity is scheduled for July 1 of this year. Transmission lines are included in the project which will cost $7,798,000.

Land Reclamation

✦ **Central Valley Project** — Work on the Central Valley project in California during 1936 was limited to investigational work at the Friant dam and reservoir site on the San Joaquin River, the Kennett and Table Mountain site on the Sacramento River, and the Baird site on the Pit River. Other work in progress included surveys for the 157-mile Friant-Kern canal, the 41-mile Madera canal, the 40-mile Contra Costa canal, and Southern Pacific Ry. relocation at Kennett. The purpose of the project is to provide a supplemental water supply for lands in the San Joaquin Valley by storage at Friant Dam, and transporting waters from a storage reservoir on the Sacramento River to the San Joaquin River. Regulation of the Sacramento will improve navigation, reduce floods and provide water for power development. The estimated cost of the project is $170,000,000. At the end of the year the Bureau of Reclamation had five construction contracts ready for bidding.

✦ **Imperial Dam**—Construction is well along on Imperial Dam which will divert water from the Colorado River into the All-American Canal. By the end of 1936 concreting at both ends of the dam had been well advanced with some of the piers practically completed; diversion of water from the main river channel was scheduled for August, 1937. The dam is of the hollow-concrete or "floating type"; no attempt will be made to carry foundations to bedrock in the river channel. The adjacent desilting plant, extending for 3,000 ft. along the river bank on the California side, is well under way and machinery is being assembled.

✦ **All-American Canal** — Construction was under way throughout 1936 on the All-American Canal which is to convey 15,155 sec.-ft. from the Colorado River for irrigation in Imperial Valley. By the end of the year canal excavation was 85 per cent complete; large draglines using 14- and 16-cu. yd. buckets had worked part way through the sand dunes and months of observation of sand storm effects indicated that with the design used sanding up the canal will not be a serious danger.

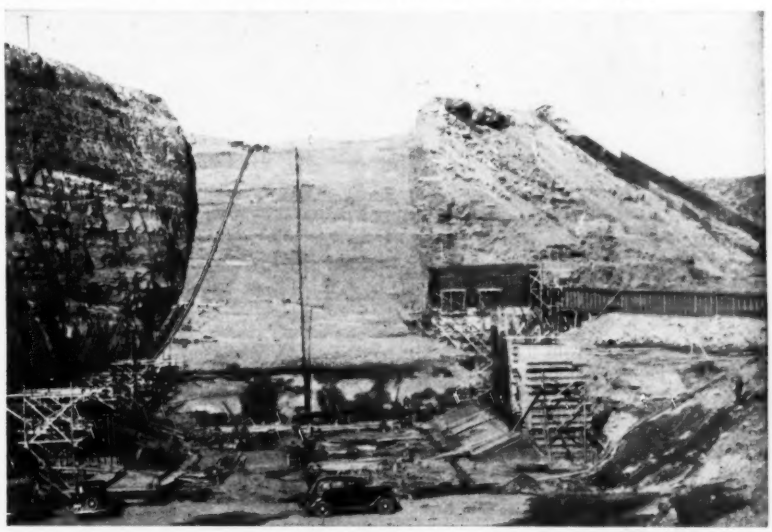
✦ **Gila Project**—The first construction contracts on the Gila Project in southwestern Arizona were awarded in March, and covered earthwork and tunnels on 17 miles of the Gravity Main Canal. Work now authorized comprises the construction of the first unit of the project including 140,000 acres, with a total estimated cost of $20,500,000. The canal will have an initial capacity of 1,920 sec.-ft. under present construction, to be increased later to carry 6,000 sec.-ft. for the ultimate 585,000-acre project. The two tunnels through the Laguna Mountains are 20-ft. in diameter and have a total length of 5,900 ft. Contracts already let total $955,000 and were 18 per cent completed at the end of the year.

✦ **Salt River Project**—A contract for construction of the Bartlett Dam on the Verde River in Arizona was awarded in July. The dam is of the concrete multiple-arch type, with a maximum height of 270 ft., highest dam of its type in the world. At the end of the year the structure was nine per cent completed. Other contracts awarded during the year covered alterations to the spillways at Roosevelt and Stewart Mountain dams; alterations to the Horse Mesa Dam spillways and construction of an auxiliary spillway; and the reconstruction of the power canal diversion dam at Roosevelt Reservoir. The value of these five labor contracts is $3,100,000. The total cost of the proposed work is $6,894,000.

✦ **Uncompahgre Project**—Work was in progress during the year on the 168-ft. earthfill Taylor Park Dam on Taylor River near Almont, Col., which will store 106,230 acre-feet of water as a supplemental supply for the project. At the end of the year the structure was 59 per cent completed. Other work in progress included canal lining and concrete structures on the South and West canals. The total cost of the dam and work on the tunnel and distribution system is $2,725,000.

✦ **Boise-Payette Project**—The Payette division of the Boise project, Idaho, comprises 47,000 acres within the Black Canyon Irrigation District. The main canal of 1,090 sec.-ft. capacity diverts from the Payette River at the completed Black Canyon Dam. In January, 1936, a contract was awarded for constructing four 14-foot diameter tunnels totaling 6,800 ft. in length. Other work started during the year consisted of earthwork, tunnels, bench

SPILLWAY OF ALAMOGORDO DAM being built on the Pecos River in New Mexico. This spillway channel, cut into the rock, is to be lined with concrete. The dam, an earth and rock fill, is to be at the right.



OUTLET WORKS of one of the 14 dams being built for flood control in the Muskingum Valley in Ohio. This is the combined spillway and outlet works of the Charles Mill Dam seen from the reservoir side.

flume, canal lining and structures on four miles of the main canal. The total estimated cost of the Payette division is $6,678,300 and the work is 10 per cent completed.

✦ **Upper Snake River Storage**—This project contemplates construction of storage reservoirs in the Upper Snake River basin in Idaho and Wyoming to supplement the irrigation supply for lands in the Snake River Valley. Work was continued on the Island Park Dam on Henrys Fork about 40 miles above Ashton, Idaho, and at the close of the construction season the dam was 65 per cent completed. The structure is a rock-faced earthfill 80 ft. high and forming a reservoir of 114,000 acre-ft. capacity. In August a contract was awarded for construction of the Grassy Lake Dam on Grassy Creek in the northwestern corner of Wyoming. It is of the earthfill, rock-faced type, 120 ft. in height and will store 15,000 acre-ft. The cost is $2,000,000.

✦ **Moon Lake Dam**—The Moon Lake project in Duchesne County, Utah, comprises 65,000 acres for which supplemental storage will be provided in the Moon Lake reservoir of 30,000 acre-ft. capacity. Moon Lake Dam is an earthfill, rock-faced structure, 90 ft. high. At the end of the year it was 59 per cent completed. Other work under construction during 1936 included the Midview Dam, a 47-ft. earthfill, the 21-ft. Midview dike, and the 6-mile Midview lateral. The 22-mile Duchesne feeder canal from Duchesne River to Lake Fork was completed in October. The estimated cost of the project is $1,340,000.

✦ **Ogden River Project**—Work was in progress during the year on the 100-ft. Pine View Dam, an earthfill, rock-faced structure on the Ogden River, storing 41,000 acre-ft. of water for the irrigation of 19,000 acres in Box and Elder counties. At the end of the year the $678,000 labor contract was 96 per cent completed. The Ogden-Brigham tunnel, 4,200 ft. in length, on the Ogden-Brigham Canal, was completed in April, and 11 miles of the canal were completed in November. A contract for an additional 11 miles of canal was awarded in November. This contract also included the 7-mile South Ogden Highline Canal. A separate contract for the Ogden Canyon siphon was awarded in December. The estimated cost is $4,213,000.

✦ **Yakima-Roza Project** — Work was started during the year on the Yakima Ridge Canal, 110 miles in length and 2,200 sec.-ft. capacity, which will divert from the Roza Dam on the Yakima River, to supply water for the irrigation of 72,000 acres on the Roza division. Contracts were awarded for the construction of two tunnels totaling 5 miles in length, and 5 miles of canal. In December bids were received for an additional 9,577 ft. of the canal. At the end of the year the project was 6 per cent completed. The total estimated cost of the proposed work, which will include diversion dam, 10,000-kw. power plant, main canal, pumping plants and laterals is $15,000,000.

✦ **Owyhee Project**—Work on the Owyhee project in Oregon-Idaho during the year, consisted of earth excavation and building structures on canals and laterals. The 80-inch plate-steel Malheur River siphon, 4½ miles in length, on the North Canal, was completed in June.

✦ **Casper-Alcova Irrigation Project**—Work on the compacted earth-fill Alcova diversion dam and diversion tunnel is 66 per cent completed. Seminoe Dam and power plant is 19 per cent complete. The spillway and diversion tunnels have been holed through. Concreting of the dam is to start in April, 1938, and be completed by Sept. 30, 1939. On the 60-mi. Casper canal four tunnels aggregating 2 mi. in length are 41 per cent complete. Government forces have completed 14½ mi. of canal. Construction on canal structures will start in the spring. Construction of the whole distribution system is 25 per cent complete.

✦ **Bull Lake Dam**—The construction of Bull Lake Dam on Bull Lake Creek to provide 145,000 acre-ft. of storage for lands on the Riverton project in central Wyoming was started in April. It is an earthfill, rock-faced structure 75 ft. in height, 3,400 ft. long. The dam was 39 per cent completed at the end of the year. The cost is $1,000,000.

✦ **Shoshone-Heart Mountain Project**—A contract for construction of three tunnels on the Shoshone Canyon Conduit, awarded in December 1935, was in progress during the year and was 48 per cent complete on Dec. 31. The Heart Mountain division of the Shoshone project comprises 41,000 acres lying northeast of Cody, Wyoming, and the estimated cost of construction is $6,500,000.

Bridge Construction

✦ **Golden Gate Bridge**—Across the entrance to San Francisco Bay stiffening trusses were slung from completed cables of the 4,200-ft. Golden Gate Bridge span during 1936. By the end of the year cable wrapping was within a month of being completed and the floor system was practically ready for concrete paving. Celebration of completion of the structure has been set definitely for May, 1937. By that time, also, the 1,742,000 cu. yd. grading contract for the 3.4-mile approach road on the north end of the bridge is to be completed.

✦ **San Francisco-Oakland Bay Bridge**—Ready for some six months ahead of schedule, roadways for vehicle traffic on both decks of the San Francisco-Oakland Bay Bridge were opened to traffic Nov. 12. Contracts have been let for signals

and interlocking systems to serve the interurban tracks on the lower deck. Work remaining to be done, including terminal facilities in San Francisco, is scheduled for completion in 1938.

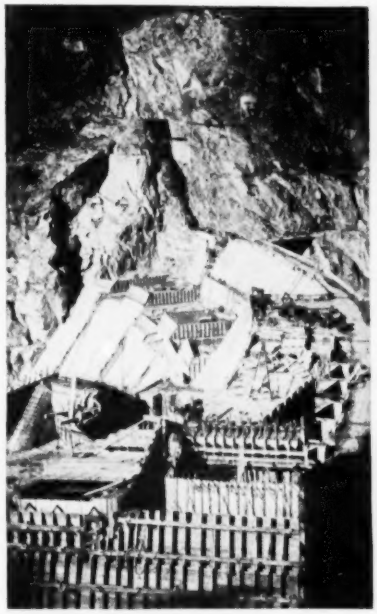
✦ **First Narrows Bridge, Vancouver**—Contracts were let in 1936 for this 1,550-span suspension bridge with a 200-ft. shipping clearance over the harbor entrance, and preliminary work was begun. Side spans are 575-ft. and there is a 3,000-ft. viaduct approach on the north. The deck consists of a 29-ft. roadway and two 5-ft. sidewalks.

✦ **Neches River Bridge**—Foundation work on the 75 piers of this 7,750-ft. bridge near Port Arthur, Texas, was about 60 per cent complete at the end of the year; the eight piers near the center are caissons extending 90 to 100 ft. to rock, the remainder being supported on piles. Erection of the superstructure, consisting of plate girder and deck truss approaches to a cantilever bridge with a 680-ft. main span and 374-ft. anchor spans supported on tall steel towers, is scheduled to begin soon.

✦ **Chicago Bridges**—Under the bridge construction program of Chicago the $878,000 Halsted St. bascule bridge was put in service in 1936, substructure on a similar $1,214,000 bascule at South Ashland Ave. is 15 per cent completed; March 1, 1938, is the completion date. A vertical lift bridge costing $1,500,000 over the Calumet River at Torrence Ave. is 75 per cent done. Difficulties over right-of-way are holding up work on the $3,250,000 North State st. bridge.

✦ **Connecticut River Bridge**—Foundations for this 3,420 ft. long bridge at Middletown, Conn., were brought to virtual completion during the year. These consist of concrete piers on steel H-piles for the plate girder approaches and on steel cylinders, 8½ to 11½ ft. in diameter, sunk 100 to 120 ft. by the rotating caisson method, for the two 600-ft. tied steel arches over the channel. Steel erection is scheduled for completion in 1937.

✦ **Triborough Bridge**—Opened to traffic on July 11, this New York City project consisting of 3½ miles of bridge structure and 14 miles of approach roads was complete at the end of the year except for a 20-block East River Drive approach in Manhattan. Its features are a 1,385-ft. span suspension bridge 98 ft. wide between cables, a 310-ft. lift span and an elevated wye intersection of reinforced concrete.



O'SHAUGHNESSY DAM in California is being raised 85 ft. from the level of the crest at the right to that of the tunnel portal in the upper center. About half the concrete had been placed at the end of the year. The dam, 427 ft. high, will add 154,000 acre-ft. of storage to the Hetch-Hetch supply of San Francisco.

✦ **Outer Drive Bridge, Chicago**—A full year's work on the $11,600,000 Chicago Outer Drive Bridge project has resulted in bringing it to within 40 per cent of completion. Opening is scheduled for late in 1937. All substructure work is finished, the north approach is 60 per cent completed and the bascules over the Michigan Canal and the Chicago River are respectively 50 and 85 per cent complete. The approach viaduct running south to Randolph St. and including the spur viaduct along Randolph St. west to Michigan Ave. is 50 per cent complete. Work on the extension of the 8-lane drive north to North Ave. is actively under construction by the Chicago Park District.

✦ **Marine Parkway Bridge**—Foundations were completed during the year and and the 540-ft. lift span of this 3,750-ft. bridge across the entrance to Jamaica Bay, New York, was floated into position. Work is proceeding on the erection of the two 540-ft. fixed spans and the continuous deck truss approaches.

Miscellaneous

✦ **San Francisco Fair** — The site for the Golden Gate International Exposition to be held in San Francisco in 1940 is being built up in the Bay with dredged material. About 12,000,000 of the total 19,000,000 cu.yd. required was in place before the end of the year and 85 per cent of the sea wall of rock around it had been completed. The area being filled in is about 5,000 ft. long by 3,000 ft. wide and has been connected by a roadway with Yerba Buena Island, the midway point on San Francisco-Oakland Bay Bridge.

✦ **New York World's Fair**—Grading work requiring the movement of 6 million cubic yards of excavation on the 300 acres of ash dump and 800 acres of swamp land comprising the site was 85 per cent complete at the end of the year. Contracts were let for some of the necessary highway bridges, and designs were under way for most of the major buildings. The Fair is scheduled to open in 1939.

✦ **Rockefeller Center, New York**—What is probably the last major building in this 3-block skyscraper development was brought to virtual completion at the end of the year. A 34-story office building, it was one of the few tall buildings under construction in the country.

✦ **West Side Highway, New York**—On this Hudson River waterfront express road, the 4-mile elevated portion below 72d St. was brought to final completion by construction of the section between 46th and 59th Sts. Above 72d St., framing and paving of the elevated portion over the New York Central Railroad

HENRY HUDSON BRIDGE, 800-ft. hingeless steel arch over the Harlem River at New York.

tracks to 82d St. was practically complete. Here the roadway comes down to a fill along the waterfront on which work is beginning. Beyond 125th St., the highway will again become elevated, and designs for this section are well advanced.

✦ **Henry Hudson Parkway**—At about 200th St. the West Side Highway, New York, connects with Henry Hudson Parkway, and this 4½-mile traffic artery containing an 800-ft. hingeless steel arch over the Harlem River was opened to traffic during the year.

✦ **Long Island Parkways**—Several new links in the comprehensive system of Long Island parkways were completed and designs for others were well advanced during 1936. In Queens, the 5½-mile Grand Central Parkway Extension from Kew Gardens to the Triborough Bridge was opened and designs were completed for the 6-mile Southern Parkway connecting Laurelton Parkway with Linden Boulevard. In Brooklyn, the 1-mile Shore Parkway around Fort Hamilton was opened, work continued on Marine Parkway and designs were well advanced for the Marine Parkway Spur. In Nassau county, the 3-mile Bethpage Parkway was opened and plans were advanced for extending Northern State Parkway from its present terminus near Mineola some 10 miles across the island to the parkway leading to Jones Beach.

✦ **Galveston Causeway**—On the new Galveston Causeway being built alongside the existing structure at a cost of $2,000,000 the two abutments are completed, 8 piers of the 121 are completed and work is in progress on 6 others. The deck work is starting. Bids will soon be asked on the drawspan.

✦ **Queens-Midtown Tunnel, New York**—Construction of a vehicle tunnel under the East River to connect the boroughs of Manhattan and Queens, New York City, was begun in October, 1936, with the start of work on the construction shaft in Queens. Contract for the Manhattan ventilating shaft was let in December, as was a contract for the cast-iron lining of the tubes. Bids will be called on the tubes within a few weeks. The tunnel will consist of two tubes, 31-ft. in diameter, and 7,790-ft. long between portals. The cost is estimated at $58,365,000.

ONE OF FIFTY PWA housing projects that were under construction during 1936, Lakeview Terrace in Cleveland was the most notable from an engineering standpoint because of its location on a steep hillside. From bottom to top is shown the central heating plant, 44 apartment buildings and the bridgehead of the Superior high-level crossing leading to the Cleveland business district.

✦ **New York Subways**—The start of the Sixth Ave. section of the Independent Subway System in New York marks the last major step in completion of the system started in 1926. Contracts have been let for all sections between 18th and 53rd Streets, where the new line ties into the Queensborough line. The Queens line was opened as far as Kew Gardens, and will be extended to Jamaica in time for the World's Fair in 1939. The crosstown line between Brooklyn and Queens is now partly in service; it will be completed this year.

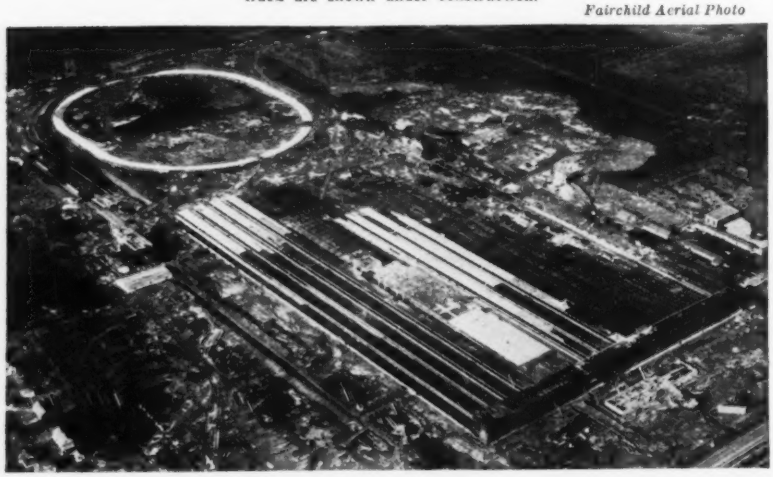
✦ **West Side Railway Line, New York**—Work on the depressed section of the New York Central relocation of its west side lines in New York was brought well along toward completion of the initial stage during 1936. Most of the bridges carrying streets over the tracks have been completed. A connection to the yard at 60th St., has been made and track-laying has begun. Work on the connection to the 30th St. yard and to the elevated line south of that point is in progress. Work on the street changes is under way.

✦ **Los Angeles Union Passenger Terminal**—The joint passenger terminal project in Los Angeles in which Southern Pacific, Santa Fe and Union Pacific railroads are combining was advanced about 11 per cent during the year and was 42 per cent complete at the end of 1936. Architectural plans for the depot building itself were expected early in 1937. The two- and three-story building for mail, baggage and express, which has a length of 969 ft., is well along toward completion. During the year $144,000 was spent on the Macy St. subway. The main fill for the depot trackage was brought up to 75 per cent complete and progress was made on retaining wall, subways and ramps.

✦ **Boise City-Las Animas Rail Line**—The 111-mi. link on the Santa Fe Ry. between Boise and Las Animas shortening this road's haul from Denver to the Texas seaboard by 143 mi. was 90 per cent completed Jan. 1 and was scheduled to start operation Feb. 1. Some 4,500,000 yd. of material has been moved and 61 pile trestles built, including three ballast deck structures. Deck girder bridges were erected over the Cimarron River and Two Buttes Creek.

INDUSTRIAL BUILDINGS costing $310,000,000 were contracted for in 1936. Here the new General Motors assembly plant at Linden, N. J., with some 16 acres under a roof of welded rigid frames, and a concrete paved proving track are shown under construction.

Fairchild Aerial Photo



Status of P. W. A. Housing Projects in United States

City	Project[1]	AREA		Allotment	Family Units	Chief Architect[2]	Contractor[3]	Status
		Total Acres	% cov. by Bldgs.					
Atlanta	Techwood	24.8	19.5	$3,074,500	793	Burge & Stevens	J. A. Jones Const. Co.	Proj. 92% occupied.
	University	19.0	25.0	2,592,000	675	Edwards & Sayward	N. P. Severin Co.	Const. 99% complete.
Atlantic City	Holmes Vill.	7.6	24.4	1,700,000	277	J. Vaughn Mathis	John McShain, Inc.	Const. 92% complete.
Birmingham	Smithfield Crt.	28.3	22.5	2,500,000	544	D. O. Whilldin	Algernon Blair	Superstr. 3% complete.
Boston	Old Harbor	31.1	23.8	6,636,000	1,016	J. D. Leland	Matthew Cummings Co.	Superstr. 17% complete.
Buffalo	Kenfield	65.4	11.8	4,855,000	658	Chester Oakley	Fleisher Eng. & Con. Co.	Superstr. 45% complete.
Cambridge, Mass.	New Towne Crt.	8.8	20.0	2,500,000	294	Henry C. Robbins	John Bowen Co.	Superstr. 13% complete.
Camden, N. J.	Westfield Acres	25.2	15.3	3,176,161	515	Joseph N. Hettel	Anthony P. Miller, Inc.	Superstr. 7% complete.
Charleston, S. C.	Meeting St.	15.6	14.6	1,350,000	212	Samuel Lapham, Jr.	J. A. Jones Constr. Co.	Superstr. 25% complete.
Chicago	Jane Addams Hs.	17.4	24.2	5,000,000	463	John A. Holabird	Maurice L. Bein, Malkov Lumber Co., Inc.	Const. 1% complete.
	do Addition	6.3	30.3	1,950,000	304	John A. Holabird	S. N. Nielsen Co.	Superstr. 30% complete.
	Julia C Lathrop Homes	35.3	21.0	5,942,000	925	Robert S. DeGolyer	Henry Ericsson Co. and U. S. Fireproofing Co.	Superstr. proceeding.
	Trumbull Park	20.9	17.8	3,038,000	462	John A. Holabird	George A. Fuller Co.	Superstr. 18% complete.
Cincinnati	Laurel Homes	23.8	22.0	6,500,000	925	Frederick W Garber	Six joint contractors.	Superstr. proceeding.
Cleveland	Cedar-Central	18.2	25.0	3,384,000	650	Walter R McCornack	George A. Fuller Co.	Const. 90% complete.
	Outhwaite Homes	20.8	26.6	3,650,000	579	Maier Walsh & Barrett	George A. Fuller Co.	Const. 66% complete.
	Lakeview Terr.	22.3	22.4	3,800,000	620	Joseph L. Weinberg	Madsen Construction Co.	Const. 55% complete.
Columbia, S. C.	University Terr.	4.1	26.0	706,000	122	James B. Urquhart	T. A. Loving & Co.	Superstr. 30% complete.
Dallas, Texas	Cedar Springs	22.3	15.9	1,020,000	181	Walter C. Sharp	A. J. Rife Co.	Superstr. 20% complete.
Detroit, Mich.	Brewster	27.3	23.4	5,500,000	699	George D Mason	Martin & Krausmann (Fnd.)	Fnd. Com. Super. being revised.
	Parkside	30.6	19.9	4,500,000	779	George D. Mason	Walbridge, Aldinger Co. (Fnd.)	Fnd. Com. Super. being revised.
Enid, Okla.	Cherokee Terr.	4.8	20.2	557,100	80	George Blumenauer	D. C. Bass & Sons	Superstr. 3% complete.
Evansville, Ind.	Lincoln Garden	11.1	16.4	1,000,000	138	Edward J. Thole	A. G. Ryan & Sons (Fnd.)	Fnd. com. Super. being revd.
Indianapolis	Lockefield Gar.	22.1	19.2	3,207,000	748	Wm. Earl Russ & Merritt Harrison	N P. Severin Co.	Constr. 73% complete.
Jacksonville	Durkeeville	20.2	13.3	1,000,000	215	Mellen C. Greeley	H. S. Baird, Inc.	Superstr. 56% complete.
Lackawanna, N.Y.		12.0	....	1,500,000	268	Harry F. Hudson	.....	Not advertised.
Lexington, Ky.	Blue Grass Pk.	67.8	6.8	1,704,000	286	Hugh Meriwether	Walter Butler Co.	Superstr. 19% complete.
Louisville	La Salle Place	13.5	21.4	1,370,000	210	E. T. Hutchings	T. L. James & Co.	Superstr. 20% complete.
	College Court	5.2	29.0	758,000	125	E. T Hutchings	Coath & Goss	Superstr. 7% complete.
Memphis	Dixie Homes	42.3	17.0	3,400,000	633	J. Frazer Smith	S. & W Constr. Co.	Superstr. 8% complete.
	Lauderdale Crt.	26.0	19.5	3,128,000	449	J Frazer Smith	T. L James & Co.	Superstr. 8% complete.
Miami	Liberty Square	63.0	8.0	970,000	243	P E. Paist and Assoc.	Walter Butler Co	Constr. completed.
Milwaukee	Parklawn	42.1	17.3	2,800,000	518	Gerrit J. DeGelleke	George A Fuller Co.	Const. 90% complete.
Minneapolis	Sumner Field	31.5	20.0	3,500,000	451	Wilbur H. Tusler	Johnson Drake & Piper	Fnd. com. Super. being revd.
Montgomery, Ala.	Riverside Hgts.	13.8	18.4	403,000	100	Ausfeld & Jones	T L. James & Co.	Const. complete.
	Paterson Crts.	71.1	30.0	522,000	156	Carl B. Cooper & Moreland G Smith	T L James & Co.	Const. complete.
Nashville	Cheatham Place	22.2	15.0	2,000,000	314	Richard R. Clark	Foster & Creighton Co.	Superstr. 16% complete.
	Andrew Jackson	20.9	18.0	1,500,000	398	Richard R. Clark	Bush Building Co. (Fnd.)	Fnd. com. Super. being revd.
New York	Wmsburg Houses	25.0	33.0	12,634,000	1,471	R. H Shreve	Starrett Bros. & Eken	Superstr. 13% complete.
	Harlem Hss.	8.5	34.5	4,219,000	574	A. M. Brown	Cauldwell-Wingate Co.	Superstr. 35% complete.
Oklahoma City	Will Rogers Crt.	36.8	12.5	2,000,000	354	J .O. Parr	Leo Sanders	Superstr. 33% complete.
Omaha	Fontenelle Hs.	15.4	20.5	2,000,000	284	W. L. Steele	Peter Kiewit Sons	Superstr. 1% complete.
Philadelphia	Hill Creek	24.0	14.0	2,260,000	258	Walter H. Thomas	Turner Constr. Co.	Superstr. 16% complete.
Schenectady	Schonowee Vill.	7.3	18.0	1,500,000	207	R. L. Bowen	Hanrahan Brothers (Fnd.)	Fnd. com. Super. being revd
Stamford, Conn.	Fairfield Crt.	4.5	24.6	929,000	146	Wm. J. Provoost	C. J. Maney Co. and New England Fnd. Co.	Superstr. 40% complete.
Toledo	Brand Whitlock	15.8	20.8	2,000,000	264	Harold H. Munger	Ring Construct. Corp.	Superstr. 1% complete.
Washington D.C.	Langston	13.8	21.1	1,842,000	274	Hilyard R. Robinson	Coath & Goss	Superstr. 1% complete.
Wayne, Pa.	Highland Homes	2.1	20.4	344,000	50	H. Bartol Register	Edward Fay & Sons	Superstr. 15% complete.

NOTES:—[1] Building types include 1 and 2-story group houses, 2 story flats and 3, 4 and 5-story apartments.
[2] Offices of architects are in same city as project.
[3] These are superstructure or general contractors, except as noted; separate contract for foundations in most cases.

Flood Control Begun

Great floods of last March forced Congress to inaugurate first federal flood-control policy, based on local participation, whose execution has been turned over to army engineers . . . Countrywide series of projects authorized at ultimate cost of over three hundred millions

•

EDITOR'S INTRODUCTION

RESPONSIBILITY for making surveys and preparing plans for flood-control projects was placed upon the Corps of Engineers by the flood-control act of 1936. Congress, in so placing the responsibility, recognized that the army engineers, over a period of years, had been engaged in making comprehensive studies of the major rivers of the country for navigation, flood control and power and thus were best able to undertake the preliminary studies for the specific projects tentatively approved under the act. General Pillsbury, as Assistant Chief of Engineers, has been in close touch with these studies since they were initiated. For that reason he was asked to prepare the following statement outlining the scope and status of the work.

Brig. Gen. G. B. Pillsbury
Assistant Chief of Engineers, U. S. Army, Washington, D. C.

IN MARCH, 1936, floods of unprecedented magnitude suddenly inundated the river valleys of the northeastern section of the United States, and inflicted damage to numerous cities and towns in amounts aggregating many hundreds of millions of dollars. Nearly two hundred lives were lost. Transportation on many rail and highway routes was paralyzed for days or weeks and the effects of the flood were indirectly felt throughout the nation. An insistent demand arose that the federal government lead in the construction of works to prevent a repetition of such disasters, and as a result a general flood-control act, often referred to as the Omnibus Flood Control Act, was passed by Congress and approved by the President on June 22, 1936.

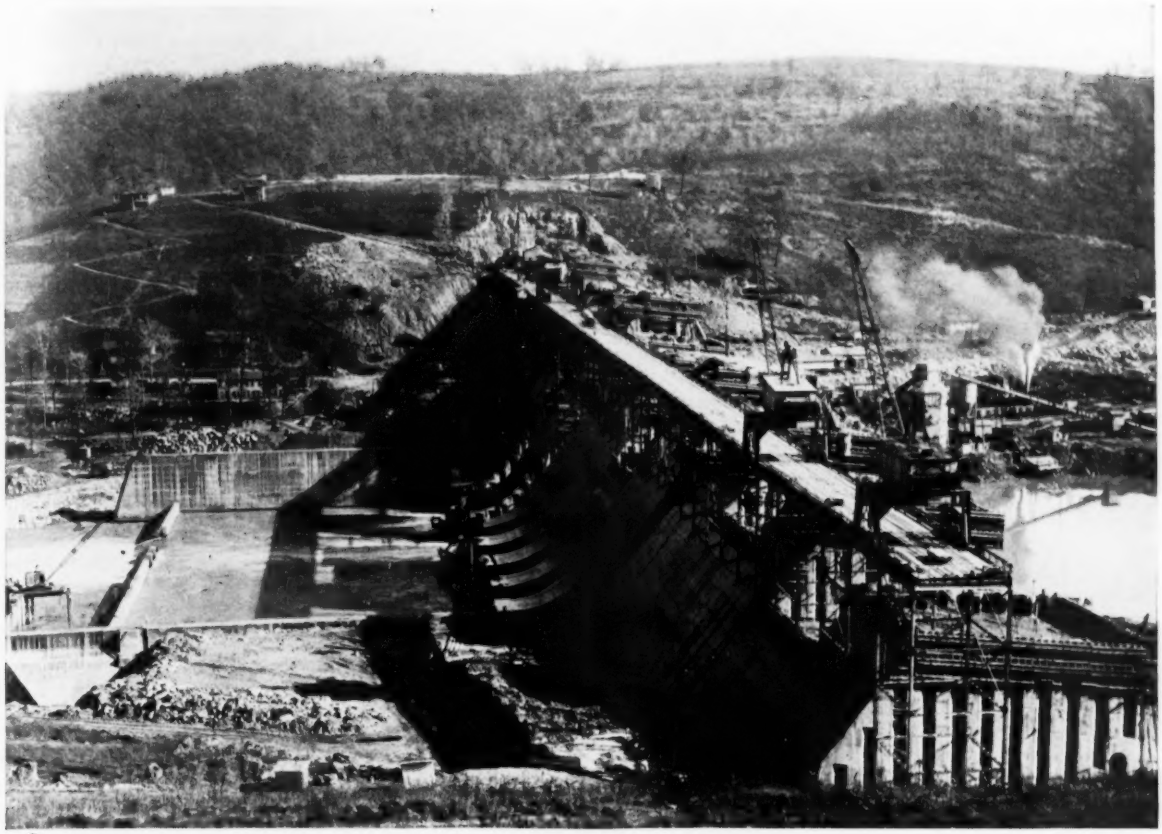
The alluvial lands in our river valleys afford soil which is generally the most fertile and provide the most effective locations for industries, railroads and cities. Their occupation and utilization is indispensable to the public welfare. Generally speaking, such lands are inherently subject to the hazard of flood. Common prudence prevents the occupation of the tracts that are frequently overflowed, but does not deter the occupancy of lands that are flooded only at infrequent intervals. The hazard is silently accepted, like the hazard of fire, earthquake, tornado or hurricane; but the structures erected on such lands intensify the damage when an unusual flood does occur, since they constrict the area through which the flood waters may escape. In many parts of the country large tracts of valuable land which once were frequently overflowed have been reclaimed by levees, dikes and drainage. The curtailment of the flood channel because of such works often greatly increases flood heights, and great damage is suffered when large floods occur.

While the hazard of damage from flood usually can be overcome by the construction of flood control works, the cost of the flood-control reservoirs, levees and channel enlargements necessary to that end is so great that such works are rarely undertaken until their need is forcibly impressed by a disaster. Thus the flood-control works on the Miami River in Ohio, designed to protect Dayton and other cities against flood damage, would not now be in existence had these cities not suffered the disastrous flood of 1913. The cost of effective flood-control works often exceeds the resources of the communities to be benefited. When the works extend into two or more states, the difficulty in negotiating interstate agreements on the execution of the work and the apportioning of the costs presents a formidable obstacle to accomplishment.

Initial federal undertakings

The federal government has for many years taken part in the construction of flood-control works for the protection of the alluvial valley of the Mississippi River, which extends from the confluence of the Ohio to the Gulf of Mexico. The prevention of flood disaster in this region is a work of magnitude vastly exceeding that in any other basin. The alluvial valley extends through seven states. Federal participation in the project was originally based on the ground that levees for the confinement of flood waters would improve the channels of the river for navigation; but since 1917 the work has been recognized as essentially for the purpose of flood control. The scope of the project has been gradually extended to include the construction, with local contribution, of levees on the upper river to Rock Island, and on outlets and tributaries as far as the flood heights are affected by backwater from the Mississippi; and to the emergency repair of levees on any tributary of the Mississippi. Contemporaneously with the flood control project for the Mississippi, federal participation was authorized in the flood-control works on the Sacramento, in California, an extensive project which has been carried out with state cooperation.

Many flood control works have been constructed by municipalities and organized districts. The works accomplished by the Miami Conservancy District are well known. A major project for the protection of the City of Los Angeles and adjoining municipalities has been prosecuted for a number of years under the Los Angeles Flood Control District. Progress on this project recently has been accelerated by the application of federal work-relief labor on a large scale under the supervision of the Chief of Engineers. A comprehensive project for the construction of fourteen reservoirs for flood protection and water conservation in the Muskingum watershed in Ohio was included in the Public Works program, and is approaching completion. The construction of the dams and the necessary relocation of public utilities is being carried out at federal cost under the Chief of Engineers, the cost of the lands and flowage being met by the Muskingum Conservancy District. The Tygart Dam and reservoir, one of the reservoirs planned for the flood protection of Pittsburgh, was also included in the Public Works program



TYGART RIVER DAM near Grafton, West Virginia, will form the first of a group of reservoirs for control of floods at Pittsburgh, Pa. It is being built by the federal government to store water to facilitate navigation of the Monongahela River.

and is approaching completion. Because of its value in conserving water which will assure an adequate supply for the navigation in the Monongahela River, upon which the industries of the Pittsburgh district are dependent, the Tygart Reservoir is being constructed wholly at federal cost, and is now included in the approved program for river and harbor improvement. Two flood control reservoirs on the Winooski River in Vermont have been completed by the Civilian Conservation Corps under the Army Engineers, and a third is under construction. A contract has been entered into for initiating the construction of the Conchas Dam in New Mexico to provide flood control and water conservation on the North Canadian River, a tributary of the Arkansas. A number of other flood control works have been carried out under the supervision of the Army Engineer corps with relief labor. Until 1936, however, no comprehensive program was adopted for federal participation in the construction of flood control works.

National policy established

The flood control act of 1936 establishes a general policy for federal participation in flood control works, prescribes the local cooperation to be afforded for such construction, and authorizes the construction of an extended list of projects and the prosecution of flood control investigations by the War Department under the direction of the Secretary of War and the supervision of the Chief of Engineers, together with surveys and investigations for runoff and soil-erosion prevention on watersheds by the Department of Agriculture.

The act formally recognizes that destructive floods are a menace to national welfare. It establishes a policy of federal participation in flood-control works if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of the people are otherwise adversely affected. As an essential prerequisite to federal expenditure on a project, the states, their political subdivisions, or other responsible local agencies must agree to provide without cost to the United States the necesary lands, flowage easements and rights-of-way; to assume all damages because of the improvement; and to maintain and operate the works in accordance with regulations prescribed by the Secretary of War. The construction of a dam may, however, proceed as soon as the site has been acquired, in advance of the acquisition of flowage in the reservoir area. If the expenditures for lands, flowage easements and rights-of-way exceed the estimated construction cost set forth in the act, the excess is to be shared equally by the federal government and local interests; and if not less than 75 per cent of the benefits from a project accrue to lands outside of the state in which the project is located, the federal government is to maintain and operate the project. Provision is made for interstate compacts for the fulfillment of these terms of cooperation for interstate projects.

The printed records of the Congressional committee which prepared the bill, show clearly that the provision requiring the state or local interests to furnish the lands, easements and rights-of-way must be construed as including the requirement that these agencies must also bear the cost of the relocation of railroads, roads, and other utilities to remove them from the reservoir area. Such relocations are often a major item in the cost of the reservoir.

Many projects authorized

The act authorizes the construction of some 270 flood control projects with an estimated cost to the United States of about $310,000,000. Of this total cost, 75 per cent will be expended

THE FLOOD WALL recently built on top of the levee at Cairo, Ill., to give added safety against flood waters from the Ohio and Mississippi rivers.

for the protection of cities and towns where centers of population and concentrated property values intensify the flood hazard, and for important agricultural and industrial areas which include cities and towns. The remaining 25 per cent includes the improvement of existing works for the protection of agricultural communities, and the construction of new works for the protection of such lands now subject to overflow. These projects are based principally on the comprehensive surveys of the principal rivers of the nation, which Congress directed of the Chief of Engineers in 1927 for the purpose of formulating the most suitable general plans for improvement in the interests of navigation, in coordination with power development, flood control and irrigation. The voluminous reports on these surveys are often referred to as 308 Reports, this being the identifying number of the Congressional document in which they were recommended. They list a large number of flood-control proposals and set up their costs and benefits. The selection of the projects included in the act was made in general from the projects so listed in which the benefits exceeded the cost.

The major projects authorized by the act are nationwide in their distribution. On the Atlantic seaboard these include reservoirs and related works on the headwaters of the Susquehanna River at an estimated construction cost of $27,154,000; reservoirs on the tributaries of the Connecticut in New Hampshire and Vermont at $10,028,900; and reservoirs on the Merrimack in New Hampshire and Massachusetts at $7,725,000. Noteworthy among projects authorized for the interior are the long considered plans for construction of reservoirs for the protection of Pittsburgh and other cities in the Upper Ohio Basin at an estimated construction cost of $20,646,000, the cost of lands and damages for this project being estimated at $34,569,000; and other reservoirs in the Upper Ohio River Basin at $19,616,800.

Other major interior projects include works on the Missouri and Kaw rivers for the protection of industrially developed areas at Kansas City, Missouri and Kansas, at an estimated construction cost of $10,000,000; the Caddoa Reservoir on the Arkansas River in Colorado and four other reservoirs on tributaries of the Arkansas in Oklahoma at a total of $15,707,000. The Conchas Reservoir on the South Canadian River, a tributary of the Arkansas in New Mexico, which is already under way, is also formally authorized in this act. On the Pacific Coast, the major projects include the construction of reservoirs and principal flood channels for the protection of the Los Angeles metropolitan area at an estimated construction cost of $70,000,000; reservoirs and related works on the Santa Ana River, south of Los Angeles, at $13,000,000; and a reservoir with channel improvements on the Puyallup River in Washington for the protection of that basin and the city of Tacoma, at $4,071,000. Including the excess cost of lands and rights-of-way to be met by the United States, these major projects account for more than $216,000,000 of the total authorization of $310,000,000 in the act. The remainder of the authorization covers a wide range of levee construction, channel enlargement and related works on the Susquehanna, Potomac, Tar, Savannah, Red, Ouachita, White, Mississippi, Illinois, Minnesota, Red River of the North, Sangamon, Kankakee, Wabash, Cumberland, Columbia, Willamette, Skagit, and other rivers.

Under the established budget procedure appropriations are limited to those purposes which have been previously authorized by law. No appropriation was made in the last Congress for the execution of the works authorized in the Flood Control Act of 1936, or for the survey also authorized in the act, but funds for the prosecution of these authorized projects are included in the budget estimates presented for the consideration of Congress in the present session, and an appropriation for initiating the work is to be anticipated.

Legislation has been enacted by the states of New York and Pennsylvania to provide the cooperation required under the terms of the act on the major projects authorized in those states. State commissions have been created to negotiate interstate compacts for the fulfillment of the specified cooperation on the projects on the Connecticut and Merrimack rivers. The fulfillment of the prescribed conditions of cooperation on the projects at Los Angeles, on the flood-control reservoir above Tacoma, and for a large number of other projects, has been assured.

Early start anticipated

As has been stated, the projects included in the Flood Control Act of 1936 are, as a rule, based on general surveys made for the so-called 308 Reports. Before construction of the authorized dams can be begun, detailed borings must be made at the sites, accurate flowage maps prepared, and the detailed designs prepared for the structures. To forestall a long delay in commencing construction, allotments have been made from the emergency funds appropriated for the relief of unemployment to advance this preparatory work on these important structures on projects for which the fulfillment of the conditions of cooperation are reasonably assured. Definite plans are in preparation, after conference with municipal authorities and the officials of constituted flood control districts, establishing the grades, location and dimensions of levees and similar works which have been authorized in the act.

Thorough study needed

A critical element in the design of flood-control works is the determination of the maximum runoff which these works must meet. The floods in the northeastern portion of the United States in March, 1936, em-

phasize the fundamental fact that the maximum flood of record cannot safely be assumed for this purpose; the floods in New England streams greatly exceeded the greatest floods previously experienced in over a hundred years. It is, however, significant that the flood crest at Pittsburgh was about a foot lower than the height which extensive studies had developed as possible under the most adverse storm conditions. A sound determination of maximum runoff must rest on a study of the possible meteorological conditions in the region, rather than on the past experience of floods on the particular stream. Experienced meteorologists are making the studies that are essential to the design of dams with adequate spillway capacity.

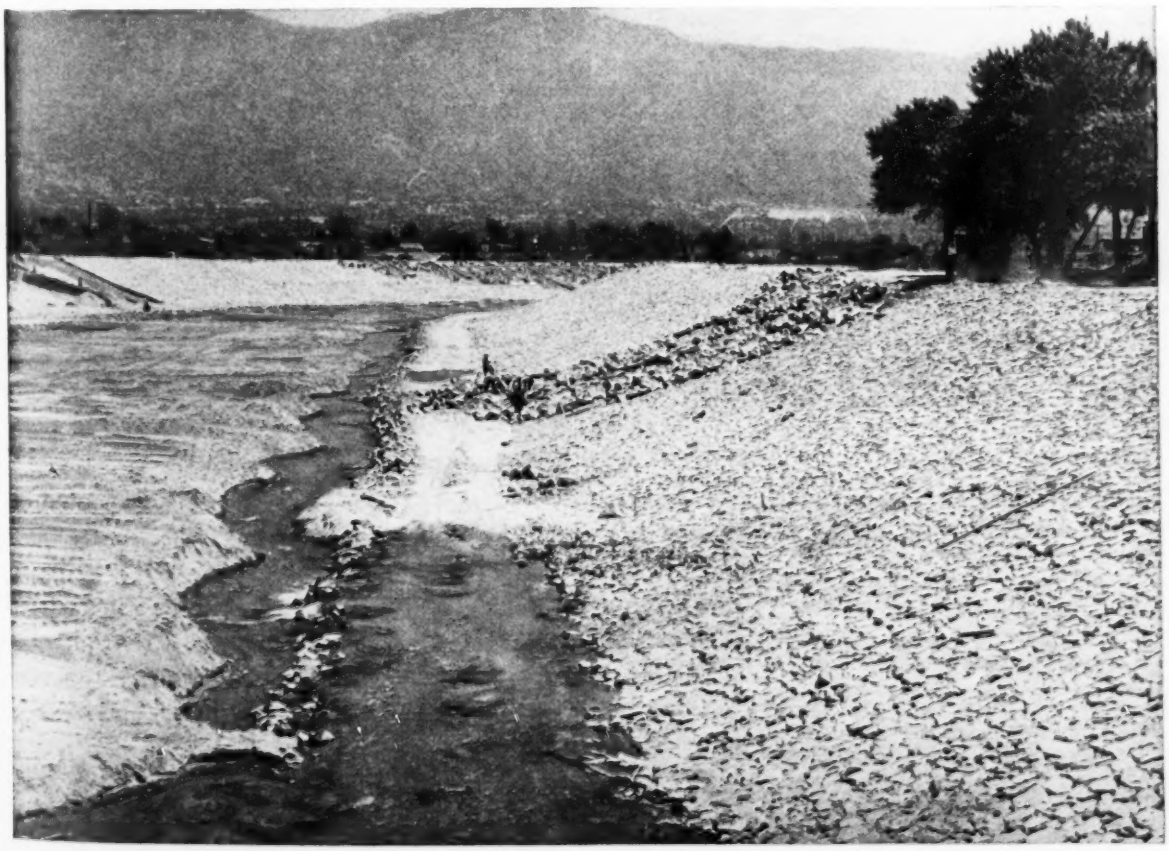
The flood-control reservoir dams to be constructed under the act are not of extraordinary dimensions, but the foundations available for some of them are such as to require sound and conservative engineering to produce safe structures. Obviously no chances must be taken with such construction, where a failure would multiply the damage that the works are built to prevent. Fortunately, the art of dam design is now so advanced that expert engineering can be relied upon to produce safe structures.

In accordance with the long established policy of the War Department, the works authorized in the act will be constructed by contract if reasonable bids are received after due advertisement, except in those special cases where the employment of relief labor becomes the dominant consideration in the prosecution of the work. In the present revival of national industrial activity, such cases may be anticipated as exceptional.

Under the terms of the act the works when completed are to be turned over to state or local agencies for maintenance and operation, under regulations prescribed by the Secretary of War, unless the benefits from the works accrue predominately to lands and property outside of the state, in which case the works will be maintained and operated by the federal government. It is not to be understood that regulations will be promulgated for the operation of works, such as levees, which are wholly of local benefit. Regulations may become appropriate to prevent the occupation and obstruction of enlarged flood channels which have been provided at national cost; but their principal occasion will arise in conserving for flood-control use, the capacity of the reservoirs that are constructed for that purpose. The record of the Miami Conservancy District indicates that the local agencies in charge of flood-control works will fully appreciate the need of conserving them for their intended use.

Besides authorizing the construction of a wide number of projects the act authorizes the survey of some 238 proposed flood control projects, if after a preliminary examination these are found to have such prospective merit as to warrant the cost of preparing detailed plans and estimates. Under the terms of the act, the feasibility of accomplishing relief by forestation, and other methods for retarding runoff and preventing soil erosion, will be concurrently considered and reported to Congress by the Department of Agriculture. These surveys will afford the basis for carrying out a sound and conservative extension of the federal flood-control activities authorized in the act of 1936.

The policy of federal aid in the construction of highways has without doubt been fully justified in the accomplishment of our great national system of public roads. Federal aid in eliminating preventable flood disasters is now an equally accepted national policy.



EXCAVATING AND PAVING flood channels for the Los Angeles River is being undertaken as part of the work of reducing flood danger.

Droughts and Floods

Abnormal weather conditions during the past year were reflected in unprecedented floods and a repetition of severe droughts. Average flow of streams was normal but groundwater levels were generally lower in the West, but without water shortage in storage reservoirs

By John C. Hoyt
Hydraulic Engineer, U. S. Geological Survey, Washington, D. C.

DROUGHT followed exceptionally high floods in the year just past. The abnormal weather and water conditions focused national attention on problems of protecting areas subject to inundation and providing methods of alleviating distress in regions where repeated rainfall deficiency is causing economic ruin.

Following an average year in 1935, the conditions prevailing in 1936 were accountable in many respects to those in 1930-34. The abnormality related more to freakish distribution than to total quantities, and as a result there were unprecedented floods in a number of rivers, and a Great Plains drought whose destructive effects equaled or approached those of 1934. The following summary of country-wide conditions is based on reports from district engineers of the U. S. Geological Survey.

Rainfall and temperature

Total precipitation for 1936 was normal in most states, but its distribution was sufficiently abnormal to produce unusual droughts and floods in many sections. As shown on Fig. 1, precipitation was below normal in 26 states and in 15 of these it was less than 85 per cent of normal; previous minima were broken in 3 states and equaled in one state.

Unusual seasonal temperatures prevailed in most sections of the country. Although no previous recorded maxima were exceeded they were equaled in 16 states. During August temperatures ranged from 99 to 125 deg., and readings over 100 deg. were recorded in all but three states; July temperature conditions were not much different than those in August. The winter of 1935-1936 was unusually severe. The temperatures during the fall and through December 1936 were above normal in most sections.

Severe wind disturbances were recorded in South Carolina, Florida, Georgia, Mississippi, Iowa, Texas, and Utah. The worst storms were in Georgia and Mississippi. In April there were at least seven major tornadoes in Georgia, causing over 230 deaths and serious injury to 1,500 people; property damage was estimated at $16,000,000 in what was said to be one of the greatest tornado disasters ever known in that state. On April 5, a severe tornado demolished an appreciable part of Tupelo, Miss., killing 216 people and seriously injuring 700 others with damage estimated at over $3,000,000.

As indicated by the annual records of streamflow, surface water in most sections approached or exceeded normal. The seasonal variation of flow, however, was unusually great and there were unprecedented floods over wide areas. Minimum flows, while low, did not generally fall below those previously recorded. This can be attributed to high groundwater levels at the beginning of the year and to ample precipitation in the headwaters of the larger streams during low-water months. The principal low flows were in the Red and upper Mississippi River basins.

At St. Louis a stage of —4.1 ft., the lowest ever recorded during the navigation season, occurred on August 28, 1936, and for twenty consecutive days the stage was lower than the previous navigation season minimum of —3 ft. recorded in July and August, 1934. The discharge for January 1934, 47,000 sec.-ft., had been regarded as being the lowest monthly discharge from 1861 to 1936, but in August 1936 the estimated flow dropped to 42,000 sec.-ft., the smallest ever recorded.

The drought situation

Drought conditions during 1936 were limited to the humid and semi-arid states. In the arid regions water supplies were average or better except for limited shortages in sections of western Montana, Wyoming, Colorado and parts of Arizona. In the humid areas the drought was confined to the Ohio and upper Mississippi River basins and New York. The areas affected were scattered both as to time and place and although severe at times in certain localities, they did not equal 1930 and 1931 conditions. In the semi-arid areas droughts of unusual severity occurred. However, they were no worse than conditions in many previous years, i.e., 1888, 1890, 1910, 1917, 1931, 1933 and 1934.

From an economic and psychological standpoint the drought of last year

TABLE I.—FLOOD FLOWS OF 1936 IN NORTHEASTERN UNITED STATES.

Stream	Location	Drainage Area, Sq. Mi	Period	Prior to 1936			March, 1936		
				Date	Gage Ht.	Discharge, Sec. Ft.	Date	Gage Ht.	Discharge, Sec. Ft.
Merrimack River	Lowell, Mass	a 4,635	b1846–1936	April 23, 1852	60.6	108,000	Mar. 20	68.4	173,000
Connecticut River	Hartford, Conn	10,480	1854–1936	May 1, 1854	c 29.8	.....	Mar. 21	37.6	285,000
Susquehanna River	Harrisburg, Pa	24,100	1740–1936	June 2, 1889	d 26.8	699,000	Mar. 19	d 30.33	740,000
Stony Creek	Johnstown, Pa	467	1889–1936	May 31, 1889	e 28.3	.....	Mar. 18	30.26	59,000
Ohio River	Pittsburgh, Pa	19,110	1762–1936	Mar. 9, 1763	39.9	.....	Mar. 18	46.0	.....
Ohio River	Sewickley, Pa	19,500	1833–1936	Mar. 15, 1907	28.0	413,000	Mar. 18	34.75	574,000
Potomac River	Point of Rocks, Md	9,651	1852–1936	June 2, 1889	40.2	460,000	Mar. 19	41.03	480,000
Kennebec River	Waterville, Maine	4,270	1892–1936	Dec. 16, 1901	135.15	157,000	Mar. 19	135.1	154,000

a Below Concord River. Net area, exclusive of diverted parts of Nashua and Sudbury Rivers and Lake Cochituate Basins, 4,424 sq. mi.
b Combined record of U. S. Geological Survey and Essex Company's record at Lawrence.
c No flood of greater magnitude is recorded by sparse records extending back to 1639.
d At Walnut Street.
e Backwater effect.

was especially serious in the semi-arid states as these areas had not recovered from the droughts of 1931, 1933, and 1934. Conditions again emphasized the fact that radical adjustments must be made in the activities in these areas if they are to become self-sustaining. The situation became so critical that the President appointed the Great Plains Area Committee to make a study and report on the best methods of alleviating the distress.

Floods

Floods of exceptional magnitude occurred during March in the northeastern states extending as far south as Virginia and west to include the Ohio River drainage above Wheeling (Fig. 2). On many streams not only were previous high records greatly exceeded but stages were higher than those of which there was any tradition. The outstanding feature of the flood, which had two peaks occurring about March 11 and 19, respectively, was its long duration and its exceedingly large total flow.

During the period March 9-22, from 7 to 15 in. of rain fell in the flood area and maxima as high as 20 in. were recorded. This precipitation fell on ground which was covered with snow from 1 ft. in the headwaters of the Potomac to over 5 ft. in northern New England. The total accumulation of water, snow and rain available for run-off ranged from 12 to 24 in. and it occurred at a time when all exposed areas were more or less frozen. In the northern areas ice jams were a major factor contributing to the floods.

Large portions of the drainage area in which the floods occurred were well protected with vegetation in the form of forest and brush lands. The floods persisted, however, on these as well as on barren and agricultural areas. With the large quantity of water available for run-off it is difficult to see that changes in forest or vegetative covering since pioneer days were responsible for 1936 floods exceeding those which had previously occurred.

While the flood of 1936 was the highest of record on many streams, shifts in the areas of maximum rainfall or in the time of the rainfall, both of which could have readily happened, would have created higher floods *and such floods are to be expected*.

Flood flows of typical streams in the northeastern United States are given in Table 2.

Excessive floods were also recorded during the year on Texas streams. Intense rains on June 30 and July 1, over tributaries of the Guadalupe River caused record flows, notably on Plum Creek. The lower Guadalupe from Gonzales to the mouth exceeded flood stage and at Victoria a record high was registered. On September 15-17 and again on the 25-28 floods occurred over a large area in western Texas in the upper Colorado and Brazos basins. The rains exceeded 27 in. in San Angelo (with unofficial records nearby running much higher) to cause one of the most disastrous floods ever experienced; it approached the maximum known in the Colorado River basin. The flood on the Brazos River reached the highest stage of record at Waco and flood stages extended down as far as Valley Junction. The estimated flow at Waco was about 250,000 sec.-ft.; the previous maximum over a 33-yr. period was 134,000 sec.-ft.

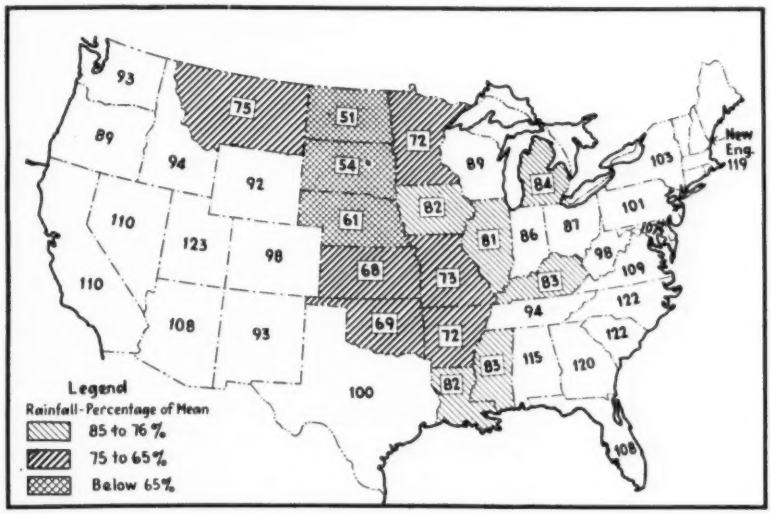


FIG. 1—DROUGHT REGION (shaded area) covered the northern Great Plains and some parts of the upper Mississippi Valley. Figures give 1936 percentage of mean rainfall.

Water supplies

Shortage of water for various uses has been largely eliminated due to the increased storage and other facilities that have been provided during the last five years. In 1936 no particularly serious shortages were reported for industrial use, irrigation needs or power production. During the first eleven months of the year there was generated at hydroelectric stations 37,296,000,000 kw.-hr., this being 36.2 per cent of the total output for the period. The average percentage of the total output produced by hydro plants for the same eleven months for the last 16 years is about 37.1—less than 1 per cent more than that for the year 1936.

On March 31, there were 10,016,000 acre-ft. storage in the principal reservoirs of the U. S. Bureau of Reclamation. On November 30 the storage in these reservoirs was 14,104,000 acre-ft. Lake Mead on the Colorado River (placed in operation in 1935) accounted for 5,800,000 of the latter quantity. Some shortages were reported in a few reservoirs but the only serious shortage was in Belle Fourch reservoir. Because of low-water in the upper Mississippi River it was necessary to suspend navigation during July and August and navigation was also interfered with on the Missouri River. The principal shortages in urban water supplies were in New York, Virginia and in the semi-arid states, especially the Dakotas where conditions were serious.

As the results of droughts in many of the Mid West states, groundwater levels last year generally declined below the levels of 1935. Measurements of water levels in wells by the U. S. Geological Survey and cooperating agencies in Wisconsin, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas indicated a general lowering of levels but with the exception of Oklahoma where there was little groundwater recharge in 1935, the water levels stood higher in 1936 than in 1934. Groundwater levels in many of the areas that were severely affected by the lack of rain in 1934 maintained stages in 1936 that were appreciably higher than in 1934, although in most cases lower than 1935. As a consequence there were few water shortages reported in these areas. The rather general recharge of the groundwater reservoirs in 1935 was sufficient to create a hold-over storage that was in many areas ample to supply demands in 1936.

Heavy precipitation and floods in the Eastern states in the spring of 1936 caused levels in many wells to rise higher than usual, some of which reached the highest levels noted in several years.

Forecasting Floodflows

Experience of the Weather Bureau shows that it is possible to forecast the amount of floodflow in large rivers with reasonable accuracy but that it is not yet possible to predict where unusual concentration of the precipitation will occur or what the total precipitation will be

●

EDITOR'S INTRODUCTION

NOTABLE advances have been made in weather forecasting in recent years. Advent of the airplane has brought the meteorologist a new tool for determining what is going on in the upper air and at the same time has made it necessary for him to make better predictions of coming weather conditions. Engineers want to know whether the newer developments in forecasting will help them in anticipating floodflows. That question was put to Willis R. Gregg, Chief of the U. S. Weather Bureau by the editors of this journal. His statement follows. Dr. Gregg believes that the bureau can be of help where the runoff from a large area is concerned, but that much remains to be learned before the small storm of intense precipitation can be forecast. At present it is possible to predict thunderstorms with reasonable accuracy.

Willis R. Gregg,
Chief, U. S. Weather Bureau
Washington, D. C.

DEFINITE PROGRESS has been made in the science of forecasting the weather since the World War. Prior to that time, methods were largely empirical and were based almost exclusively on observations of surface conditions and clouds. Later, however, with the introduction of the Bjerkness cyclone model, with its warm sector, bounded by the warm front and the cold front which met near the center of lowest pressure in the cyclone, (Fig. 1) it was possible to explain by the application of well known physical laws the occurrence of most of our usual types of precipitation. In more recent years with the increase in the number of observations by airplane, it has been possible to obtain the characteristic properties with respect to temperature, humidity and pressure of the masses of air which overlie great regions of our country from time to time. Studies of these air masses have permitted a clearer understanding of the inception of disturbances that affect our weather as well as the different kinds of precipitation that attend them. Further, it is possible from the plotting of airplane data on energy diagrams to determine the instability of the air and to ascertain the amount of lifting, either by thermal convection or by frontal action that is required to produce condensation. Such information becomes of great importance in the warm season in connection with the forecasting of thunderstorms. Formerly it was necessary to depend on the ability of the experienced forecaster to determine when and where a disturbance would originate and how rapid would be its development. From investigations of upper air data a great deal has been learned regarding the formation of fronts and the development of disturbances along these fronts. This permits estimates, having a greater degree of accuracy, as to when and where such developments will take place. Further, after a disturbance has once developed, recently devised kinematical methods with the help of the geostrophic wind scale, assist us in determining not only the direction and speed of movement of the disturbance but also whether it will increase or decrease in intensity.

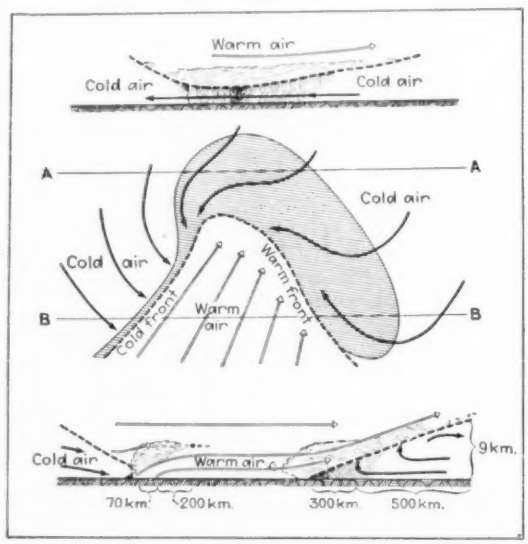


FIG. 1—THE BJERKNES CYCLONE MODEL is used to gain an understanding of weather conditions. The central part of the figure shows the wind distribution in the horizontal found in any well organized disturbance. The double arrows represent warm air currents, and the single arrows cold currents. The upper portion of the figure shows a vertical section through *AA* of the central figure, while the lower portion shows a vertical section through *BB*. The vertically hatched areas indicate precipitation.

That improvement has not been reflected in a decided increase in the percentage of accuracy of the forecasts should not be taken to indicate any lack of its reality, but more as a tribute to the reliability of the former empirical methods at least so far as the forecasts for thirty-six hours or more areconcerned.

Usually it is not the occurrence of some single meteorological event that furnishes the problem for the engineer. It seems to be rather the occurrence of a series of events extending over a period of several days, or longer. These may be caused by the passage of a succession of disturbances over similar tracks as in the Pittsburgh flood of March, 1936 (See Fig. 2), or by the persistence of a condition due to the blocking of the advance of a disturbance, as in the Hudson River Valley and New England floods of November, 1927, and the New England floods of March, 1936. In the

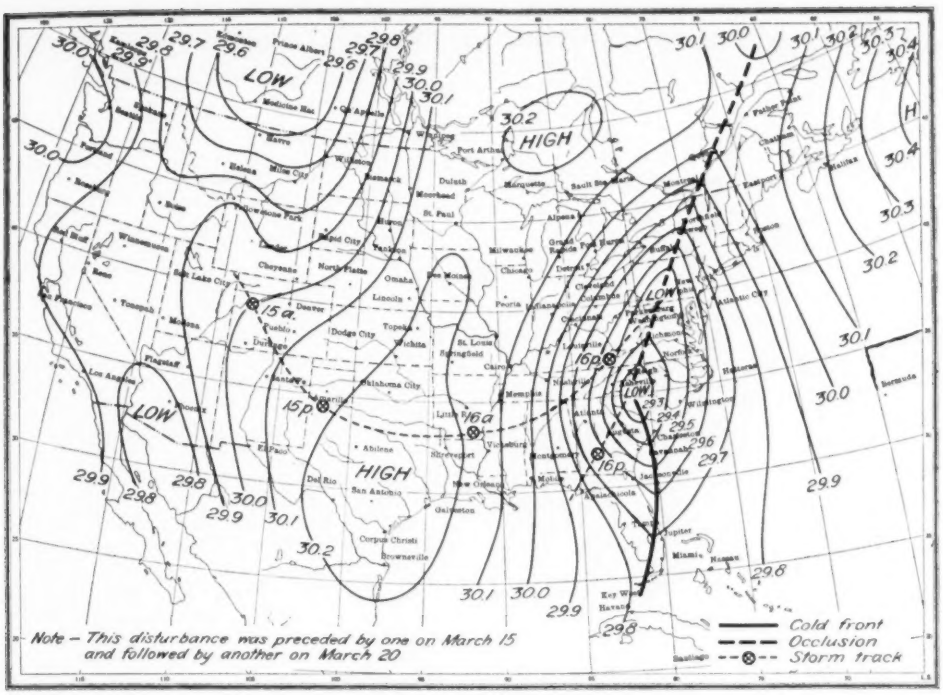


FIG. 2—HEAVY FLOOD FLOWS of March, 1936, were due to a succession of storms and, in New England, to the blocking of the storm area here shown resulting in general rains from March 16 to 19.

first case the seat of interest was the mountain region of Virginia, Maryland and western Pennsylvania. Over this area about six inches of rain fell during two days. This was caused by a succession of slow moving disturbances. With a terrain moistened to saturation in its surface layers and frozen underneath, the conditions were ideal for maximum runoff. In the case of the Hudson River Valley and New England floods of 1927, general heavy rains occurred from Nov. 2 to 4. These were occasioned by the retarded eastward movement of a disturbance of moderate character, due to partial blocking, and the subsequent development of a secondary center. The New England floods of March, 1936, were caused by the blocking of the disturbances shown in Fig. 2, which gave general rains that were fairly heavy over a considerable part of the area involved beginning the 16th and lasting until the 19th. In this particular case the stages were already high when the rains above mentioned began.

None of these conditions could have been successfully forecast more than twenty-four hours in advance.

[*This was written before the recent high water in Ohio. The storm that caused that flood was very similar to the one of last March.*—EDITOR]

Occasionally a tropical storm will bring about situations in which engineers are keenly interested, mostly however along the coast in connection with high tides and heavy seas. On other occasions tropical storms affect the interior as well as the coast, as for example in the case of September, 1928. That storm passed northeastward up the south Atlantic coast causing falls of rain averaging six inches or more in two days over portions of North and South Carolina.

In all these cases the major reason for the critical condition was an extremely heavy rainfall over a limited area during a period of two or three days. This is the type of forecast, covering two days or more, in which the engineering profession is mostly concerned.

Conditions, such as the ones instanced, are most difficult to predict on account of the involvement of some unusual feature. In most cases, it is the blocking effect due to the abnormal movement of some cold, shallow mass of air. This shallow cold mass in combination with the very warm, moist southeasterly upper current of air from the Atlantic presents a weather situation usually difficult to diagnose. It is also difficult to specify the limited area over which the abnormally heavy rains are to be expected.

Aid for engineers

That progress has been made in understanding the structure of the different air masses and their interactions as well as in forecasting qualitatively the occurrence of different kinds of precipitation cannot be gainsaid. But the point has not yet been reached in our advance where we can predict in a positive, quantitative way the results to be expected from these unusual situations. So many variables are involved and some of the processes are so complex that it is too much to hope, at least for some time to come, that we may be able to indicate these situations with positiveness sufficiently far ahead to be of the maximum aid to engineers.

Of course valuable information can be and is given to engineers engaged in the building of dams, bridges, etc., which materially assist them in their work. This information usually covers 24 hours and can be made fairly specific especially as regards minimum temperatures that may govern the pouring of concrete.

Water supply in the far West is predicated on the accumulation of snowfall in the mountains. Surveys of the depth and density of the snow cover in the upper watersheds permit calculations of the available supply of water for the coming season. To go back a step, however, and predict the snow cover brings us into the realm of long range forecasting for which dependable and satisfactory methods have not yet been developed.

While the numerous methods that have been essayed have not produced particularly encouraging results, the benefits to be derived from forecasts covering a season or a year in the future are of such importance that they not only justify but urge further investigations in this field. Earnest efforts are being made along this line in this country and other places.

Crossing Elimination

The federal government's highway-railway grade crossing elimination program summarized, progress reported and needs analyzed—Cooperation between the Bureau of Public Roads, the highway departments and railroads results in an efficient plan of operation

•

EDITOR'S INTRODUCTION

A GREAT PROGRAM of grade-crossing elimination was initiated by the federal government in 1935 and $200,000,000 was made available by the President to start the work. Thus for the first time the attack on crossing elimination was put on a national basis and the problem of finding the funds was eliminated temporarily. Three agencies are involved, the U. S. Bureau of Public Roads—in which direction is centered—the state highway departments and the railroads. Effective handling of the work calls for and is receiving close cooperation. In the following article J. G. Brennan, secretary of the committee on grade crossing elimination of the American Association of Railroads sets forth the situation as it is today and indicates what future needs must be met if the crossing hazard is to be eliminated.

John G. Brennan

Engineer of Grade Crossings, and Secretary of the Committee on Grade Crossing Elimination, American Association of Railroads, Washington, D. C.

IF ONE HAD TRAVELED, during the year 1936, over the forty-eight states, the District of Columbia and Hawaii, he would have been witness to Uncle Sam's tremendous onslaught on highway-railroad grade crossings. In a truly American fashion Uncle Sam has stripped off his coat and gone to work, with the result that many thousand men are busily engaged in making the materials, and many thousand others in building the structures to do away with a large number of the worst crossings. This amazing activity fits perfectly into his plan to relieve unemployment and at the same time do work that will be a lasting benefit to all.

The first step was to furnish the money through the Emergency Relief Appropriation Act of 1935. Soon after the passage of that act, President Roosevelt made available $200,000,000 for the elimination of hazards to life at railroad grade crossings, and since then has given his whole-hearted support and approval to the undertaking. The legislation provided that any funds allocated for highways and grade crossing elimination should be apportioned by the Secretary of Agriculture and expended under the provisions of the federal highway act which places the direction of the work under the Bureau of Public Roads. Under this federal agency, the state highway departments and the railroads are working hand in hand to accomplish the elimination of 2,103 grade crossings, the rebuilding and modernizing of 332 existing grade separation structures, and the protection of 1,166 crossings with approved types of protective devices and signals. Crossing eliminations numbering 1,077 will be accomplished by carrying the highway over the railroad, 497 by carrying the highway under the railroad, and 529 by relocation of the highway. Where existing grade separation structures are being rebuilt, 200 carry the highway over the railroad, and 132 carry the highway under the railroad.

The job is in full swing, as a glance at Table II, showing the progress by states as of November 30, 1936, will indicate.

When Uncle Sam does a job, he usually does it thoroughly. The $200,000,000 will only begin to eliminate the worst crossings, so the 74th Congress, in the federal-aid highway bill of last year (H.R. 11,687), authorized the appropriation of $50,000,000 for each of the fiscal years ending June 30, 1938 and June 30, 1939, for the elimination of hazards to life at railroad grade crossings, thus insuring the continuation of this worthy and popular program for two more years. These funds do not have to be matched with like amounts by the states as do the regular federal-aid highway funds, greatly relieving the state and railroad treasuries of the cost of construction, and insuring co-operation. The $50,000,000 for the fiscal year 1938 has recently been apportioned to the states, and the highway departments and the railroads are formulating programs and preparing plans so that the work may be placed under contract as quickly as possible.

Never before in this land, and, so far as the writer knows, in any other land, has so co-ordinated and concentrated an attack been made on the grade crossing problem. This was made possible only because the federal government has given the money to pay the cost, exclusive of land and land damage, overhead, depreciation, interest, etc., and because it is directing, through a central organization, the activities of the highway departments and the railroads, the two agencies carrying on the construction work throughout the Nation.

The problem, past and present

Prior to about 1829, there were no grade crossings in this country, because there were no railroads. The population of the country was principally along the Atlantic seaboard; west of the Alleghenies, it was largely unsettled and undeveloped. The country needed rapid, reliable transportation to open up the mines, forests and farms; to stimulate commerce and unite the people. The coming of the railroads enabled this to be brought about. In 1830, there were 23 miles of railroad; in 1840, 2,818 miles; in 1890, 163,605 miles; in 1930, 260,440 miles; and in 1935, 252,930 miles. When the railroads were first built in the Atlantic seaboard states, they crossed most of the existing streets and roads at grade. Every community wanted a railroad, and invited the railroad to come within its boundaries. To build the railroads so as not to cross the highways at grade would have increased the capital cost, and consequently the cost of transportation. Most people did not want this, and

many objected to any change in the grade of the highways.

When the railroads were built west of the Alleghenies, there were few roads. The growth in population came after the railroads. New roads and new streets had to be built to provide for the growth in population and to bring products to and from the railroads. This was true also as population increased along the Atlantic seaboard. Most of the new roads and streets were extended across the railroads at grade. The duty of protecting the crossings devolved upon the railroads. However, because travel on the highways was afoot or by horse-drawn vehicles, the grade crossing problem did not become serious until the population had increased enormously. Then cities and large villages began to demand grade crossing elimination. Carelessness and delay to highway traffic, then, as now, were the principal causes.

In 1888, the State of Massachusetts, by legislative action, appointed three civil engineers to investigate the subject of the gradual abolishment of crossings of highway by railroads at grade. It is interesting to note that they reported 75 grade crossings abolished in the state between Jan. 1, 1879 and Jan. 1, 1889, and that there was an increase of 155 new grade crossings during that period. The report states: "Gates and flagmen do not protect. They are not a barrier against a restless people, impatient of a moment's delay. If the gates effectively closed up the road, and kept the people away from the track until it was safe to cross, they would be made much better; but at present only a very few of the foot passengers pay any attention to them."

The three engineers estimated that to eliminate 2,247 grade crossings (all in the state except a few along the wharves) would cost $40,766,000. This would average slightly over $18,000 per crossing, including the land and damage. Contrast that figure with the average of about $100,000 per crossing today, and the financial magnitude of the present problem is apparent.

Not until the coming of the motor vehicle did agitation for grade crossing elimination become nation-wide. Thereafter, huge sums of money were spent for eliminations. Some indication may be given from the fact that from the year 1920 to the year 1931, Class I railroads (annual operating revenues above $1,000,000) in the United States charged to capital account for grade crossing elimination $223,165,615. In addition to capital expenditures, Class I railroads, during this twelve-year period, expended $147,135,737 for maintenance and depreciation of crossings and signs, and for the protection of grade crossings they spent $257,949,760 or a total of $628,251,112 for grade crossings. Nothing is included in this total for the growing annual interest charge borne by the railroad companies on their capital expenditures for crossing elimination. For the elimination of grade crossings, it is estimated that public authorities spend an amount equal to that spent by the railways. On this basis, the total cost of eliminating grade crossings in the United States during the six years from 1926 to 1931, approximately $50,000,000 per year, or $300,000,000 for the six years as a whole. Separation of grade benefits the railroads to some degree, but the costs of separation are largely unproductive and unremunerative. Such work adds a financial burden to railroad treasuries and to their operating expenses and taxes, and increases the cost of railroad transportation, which the public, in the last analysis, pays. The principal benefits of grade crossing elimination accrue to the highway users.

Despite the expenditure of these huge sums, grade crossings increased faster than they could be eliminated. On Class I railroads alone, as of Jan. 1, 1930, there were 242,809 highway-railroad grade crossings, the greatest number on record. On January 1, 1936, there were 234,231 crossings on Class I railroads, a reduction of 8,578 in the six-year period. How many grade crossings there are on other than Class I railroads, so far as the writer knows, it not a matter of record, and he is unable to say whether there has been a reduction of such crossings since 1930. Probably the reduction on Class I railroads is due in a large measure to the policy of the federal government of making available to the states money that could be used for grade crossing elimination.

UNDERPASS between Peoria and Glendale, Ariz., a clear opening over a four-lane road. Sweeping curves and easy grades reduce the physical hazards but cannot eliminate those introduced by careless driving.

Funds from several sources

In addition to the $200,000,000 authorized under the Emergency Relief Appropriation Act of 1935, $34,135,000 out of a total of $600,000,000 granted to the states for emergency construction of public highways and related projects, under the National Industrial Recovery Act, approved June 16, 1933, was used to pay the whole or part of

TABLE I—CURRENT STATUS OF UNITED STATES WORKS PROGRAM GRADE CROSSING PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

Status as of November 30, 1936. Compiled by the U. S. Bureau of Public Roads

STATE	Apportionment	COMPLETED					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
				Number					Number					Number			
		Estimated total cost	Works program funds	Grade crossings eliminated by separation or relocation	Grade crossing structures reconstructed	Grade crossings protected by signals or otherwise	Estimated total cost	Works program funds	Grade crossings eliminated by separation or relocation	Grade crossing structures reconstructed	Grade crossings protected by signals or otherwise	Estimated total cost	Works program funds	Grade crossings eliminated by separation or relocation	Grade crossing structures reconstructed	Grade crossings protected by signals or otherwise	
Alabama	$4,034,617	$606,753	$606,753	11		4	$2,961,384	$2,961,384	36			$313,047	$313,047	3		8	$153,434
Arizona	1,256,099	618,960	614,726	7			566,261	554,816	6								86,557
Arkansas	3,574,060	1,135,951	1,131,634	29	4		1,726,085	1,723,087	22	1		662,597	661,542	8	1	29	57,797
California	7,486,362	2,946,841	2,840,344	19	6		4,467,380	4,329,593	25	2							316,426
Colorado	2,631,567	1,076,063	1,055,063	20			868,611	868,583	7	1							707,921
Connecticut	1,712,684						563,087	491,009	3	1	1	494,014	494,014	1	2		727,661
Delaware	418,239						143,486	120,000	1								298,239
Florida	2,827,883	660,331	658,600	5	4		1,431,369	1,430,789	17	2		456,292	456,292	7			282,202
Georgia	4,895,949	12,090	12,090	1			354,170	354,170	6	2		510,359	510,359	17			4,019,330
Idaho	1,674,479	824,073	821,481	13	1		413,637	413,637	6			64,486	64,486	1		18	374,874
Illinois	10,307,184	2,423,431	2,422,894	31			5,528,177	5,528,177	32	5		2,139,800	2,139,800	11	2		216,313
Indiana	5,111,096	497,831	497,831	8			4,373,258	4,250,139	35	11		399,720	363,120			162	6
Iowa	5,600,679	1,507,566	1,460,776	40	4		3,568,132	3,531,469	59	5		691,074	574,020	11		8	34,414
Kansas	5,246,258	682,865	682,865	9		1	4,572,084	4,516,657	47	1		46,736	46,736	2		3	
Kentucky	3,672,387	265,336	265,336	7	1		2,463,277	2,173,545	13	2		134,304	134,304	1	3		1,099,203
Louisiana	3,213,467						1,447,148	1,447,148	14	1		966,512	922,046	8	3		844,272
Maine	1,426,861	493,350	493,016	12			584,695	584,103	8			81,675	81,675	1		2	268,066
Maryland	2,061,751						615,019	615,019	4	3		921,502	899,033	3	2	19	547,699
Massachusetts	4,210,833	197,672	197,672	2	1		2,634,481	2,634,481	19	2		382,770	382,770	2			995,910
Michigan	6,765,197	2,231,975	2,231,975	26	4		4,554,297	4,509,797	19	4							23,425
Minnesota	5,395,441	2,334,936	2,206,491	51	8	38	3,061,801	2,893,610	35	4	3	56,140	56,140		1	1	239,200
Mississippi	3,241,475	207,504	207,504	8	3		2,331,184	2,331,184	42		1	56,000	56,000	4		3	646,786
Missouri	6,142,153	308,981	308,981	6			5,695,929	5,499,685	46			367,252	253,300	1		2	80,187
Montana	2,722,327	2,250,014	2,250,014	32	6		403,583	403,583	5								68,730
Nebraska	3,556,441	1,441,856	1,440,533	55	1		1,588,885	1,588,885	23	1	5	434,876	434,876	5	1	20	92,147
Nevada	887,260	370,830	370,830	8			531,025	512,800	2	1		3,630	3,630			5	
New Hampshire	822,484	151,745	151,745	1	2		350,493	350,493	6	2	1						320,246
New Jersey	3,983,826	59,838	59,838		1		2,478,788	2,467,743	17	1		163,319	163,319	1	2		1,292,927
New Mexico	1,725,286	665,807	665,807	12			865,128	865,127	5	1		194,352	194,352	2			
New York	13,577,189	1,801,823	1,797,023	9	7		9,957,801	9,701,755	31	31		256,120	256,120		4		1,822,291
North Carolina	4,823,958	579,548	579,548	9	6		2,272,573	2,257,073	27	9		1,108,520	1,108,520	10	2	61	878,817
North Dakota	3,207,473	399,891	399,891	12			1,765,711	1,764,711	29	3		456,190	456,190	10	1		586,681
Ohio	8,439,897						4,393,291	4,179,991	27	3		3,202,400	3,039,096	17	4		1,220,810
Oklahoma	5,004,711	1,208,387	1,208,387	26	1		1,918,749	1,918,749	22	3		385,124	385,124	6	2		1,492,450
Oregon	2,334,204	562,923	562,923	7	3		1,804,273	1,722,133	9	3	1	38,350	38,350	1		1	10,798
Pennsylvania	11,483,613	390,192	338,959	17			6,341,869	5,792,969	42	14	9	2,221,625	2,218,877	11	3		3,132,808
Rhode Island	699,691	398,464	398,464	2	1		277,805	276,739	2	1							24,488
South Carolina	3,059,956	441,915	434,323	11	2	3	1,416,102	1,405,024	26	6		218,406	218,356		1	51	1,002,253
South Dakota	3,249,086	568,566	568,566	17	1	5	1,508,246	1,508,246	37	2	9	325,656	325,656	5	1	17	846,619
Tennessee	3,903,979	260,278	260,278	6		6	1,548,820	1,548,820	21	2	3	563,646	563,646	9	1	13	1,531,235
Texas	10,855,982	2,739,082	2,739,082	48	8		6,915,308	6,908,931	78	5		765,488	765,487	3	1	170	442,483
Utah	1,230,763	87,218	85,828	1	1		1,015,391	998,743	14			93,695	93,695	2			52,496
Vermont	729,857	461,762	457,829	7	5		204,074	187,995	1	1	9	64,345	34,745	2		5	49,288
Virginia	3,774,287	853,786	782,923	23	3		1,343,569	1,304,569	15	7		551,960	551,959	10	4	11	1,134,837
Washington	3,095,041	868,175	863,344	15	3	5	1,964,763	1,964,338	8	8		4,290	4,290			2	263,070
West Virginia	2,677,937						1,225,701	1,225,676	11	2		493,227	493,227	10	1	4	959,033
Wisconsin	5,022,683	1,661,704	1,661,704	21	2		2,785,641	2,720,560	16	4		536,470	475,000		1		165,418
Wyoming	1,360,841	251,237	251,131	4			863,106	828,101	8								281,609
Dist. of Columbia	410,804						425,564	396,804	3								14,000
Hawaii	453,703						522,380	453,703	5								
TOTALS	196,000,000	37,507,610	37,045,002	648	89	82	111,613,591	109,016,343	992	157	42	20,825,969	20,233,199	185	43	615	29,705,456

the construction cost for the elimination and protection of grade crossings and the reconstruction of existing grade-separation strucures. This program covered 690 structures, and 706 grade crossings were protected with standard signals.

The Public Works Administration lent its support by grants to states in amount of $3,185,700 for 15 projects estimated to cost $7,612,880. Some very bad crossings either have or will be eliminated as a result of these grants.

The Works Progress Administration has given excellent co-operation. This agency has 15 projects specifically listed as grade crossing eliminations. The estimated contribution of WPA funds is $1,785,869. Six of the projects mentioned above are under construction at the present time and WPA funds are involved to the extent of $1,761,220. For the semi-monthly period ended Oct. 15, 1936, these projects consumed 35,545 man-hours, and the wages paid amounted to $20,475, the average hourly earning being 57.6 cents. The WPA has participated to some extent in other grade crossing work not listed under that heading, but under some general heading such as road building. It will co-operate especially where crossings can be closed and traffic diverted by building a connecting road. Projects of this character are sponsored by a state or municipality.

Highway traffic increases

The greatest factor in the present-day demand for grade crossing elimination is the development of the motor vehicle, the consequent building of a national system of highways, and their concentrated use by the public and by private enterprise engaged in the transportation business, both interstate and intrastate. Railroad traffic, generally, has declined since the advent of the motor vehicle and the great mass of the movements over the crossings is on the highways.

One of the most serious causes of grade crossing accidents is motor vehicles running into the side of a train. For the six months ended June 30, 1936, the Interstate Commerce Commission reported that out of 1,719 accidents involving collision of motor vehicles and trains, 634 were caused by motor vehicles running into the side of the train. In these 634 accidents, 111 people were killed and 947 injured.

It is not too much to say that thousands of crossings must be eliminated to meet the demands of our present and future civilization. Thousands of others must be protected, and thousands closed entirely. Until this is done, we will continue to have large loss of life and property and delays to highway traffic.

The significance of Uncle Sam's onslaught on the grade crossing problems thus is apparent, for not until he took command was there ever a national co-ordinated movement to abolish hazards to life, and delays to traffic at highway-railroad grade crossings.

Apportionment of funds

The $200,000,000 allotted by the government through the Emergency Relief Appropriation Act of 1935, was apportioned to the states on this basis: one-half on population, one-quarter on the mileage of the federal-aid highway system, and one-quarter on the railroad mileage as determined by the Interstate Commerce Commission. The $50,000,000 for the fiscal year 1938 has been apportioned to the states on this same basis as will be the $50,000,000 for the fiscal year 1939, which will be apportioned on or before Jan. 1, 1938.

The rules and regulations of the Bureau of Public Roads pertaining to the $200,000,000 program require that, to secure a reasonably equitable distribution of benefits to the individually operated railroads in a state, projects shall be apportioned, within practical limits, to those railroads in such manner that the total cost of the project or projects on any railroad shall have approximately the same relation to the total apportionment to the state, as the mileage of railroad owned and operated by such company bears to the total mileage of railroads and operated in the state. The rules also provide that projects may be chosen without limitation as to location, except that not less than 25 per cent of the state's apportionment be expended on crossings with secondary or feeder roads, unless a lesser percentage be approved by the Secretary of Agriculture. This rule does not prevent the elimination of hazards to life at important main-line crossings of railroads which have only a relatively small mileage in any one state. All of these were wise provisions, as work was distributed over all sections of the states, and at the same time it permitted crossings to be eliminated on the great majority of railroads.

Some delay was experienced at the start because, in order to relieve unemployment to the greatest possible extent, the federal expenditure was limited to $1,400 per man per year, and 90 per cent of the labor had to be taken from relief rolls. Because of the cost of materials and the fact that considerable skilled labor is required, the cost of grade crossing work, where structures are required, runs between $2,000 and $3,000 per man per year. However, when it became apparent that the prescribed limit was holding up work the cost restriction was eliminated, but contractors were required to employ unskilled and intermediate grade labor through employment agencies designated by the U. S. Employment Service. The removal of the above restriction enabled the highway departments to formulate programs, after agreeing with the railroads on the crossings to be included, and after giving due consideration to crossings in areas where unemployment was the greatest. The programs were then submitted to the Bureau of Public Roads, and, if conforming to the requirements of that bureau, they were recommended to the President for approval. Immediately after the recommendation, the work could proceed.

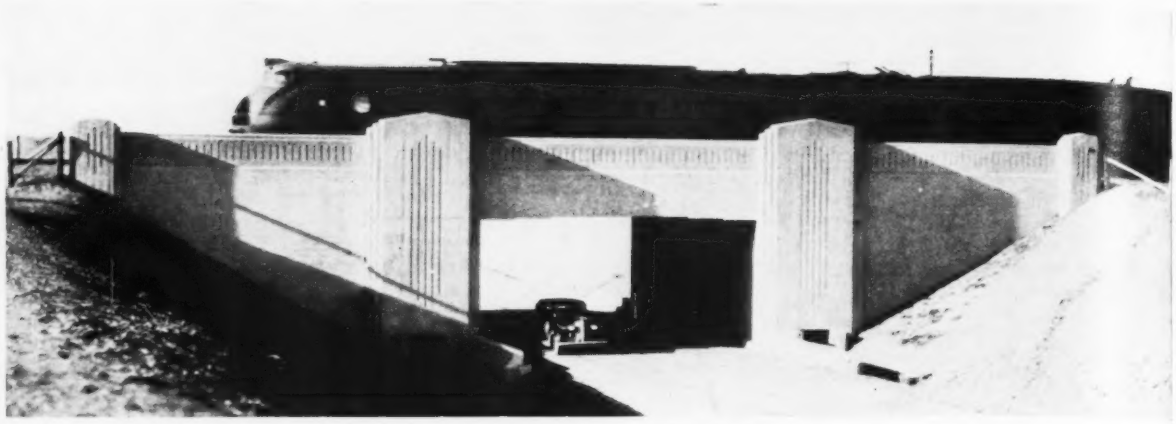
The surveys and plans are made by the highway departments, the railroads, or both. The railroads do the work necessary for the maintenance of rail traffic and the adjustment of rail facilities, and the highway departments do the remainder of the work by contract. The arrangement has worked quite satisfactorily.

The writer will not describe the types of structures being built nor the structural problems encountered. The accompanying photographs will give some idea of the types of structures. The engineers designing and building the structures are taking advantage of the most modern developments in design, materials and methods of construction. So far as it is humanly possible to plan for the future, the carrying capacity and width that are being provided for both the highway and railroad structures will be adequate. Alignment, sight distances, grades, drainage, etc., are being built into the highway facilities to give reasonable safety and free movement for high-speed traffic on the highways.

Obstacles to progress

One of the greatest difficulties and causes of delay in getting work under construction is the acquisition of the necessary land. In many cases, because money was not available for the purchase of land and the payment of consequential damages, many worthy projects could not be done. Unless some provision is made, preferably by the federal government, to finance the cost of land and damages, continuation of this delay must be expected in many states.

It is astonishing, but nevertheless a fact, that great trouble has been experienced in the past, and is being experienced at present in obtaining the consent to close grade crossings where the highway is diverted so as not to pass over a railroad grade crossing, also where structures are to be built, unless the structure happens to be on the line of the existing highway. This is especially true in the Middle West, the Far West and the South. The state laws in a number of these states do not permit the clos-



HIGH-SPEED TRAINS have made crossing elimination even more necessary than heretofore at many points. This underpass on the Lincoln Highway at Granger, Wyo., shows what can be done in the arrangement of masses to obtain a pleasing appearance with little added cost in form work.

ing without the consent of the municipality in which the road is located, or, in some cases, without the consent of the people in the vicinity. Their refusal prevents the closing of the crossings.

Direction of the work

The direction, supervision and coordination of the program by the Bureau of Public Roads is through Thomas H. MacDonald, its chief, and through the divisions of design, bridges, construction, control, information, contracts and laws, and management, located at Washington, D. C., through a regional office at San Francisco, and twelve district engineers located at strategic points throughout the country. The state highway departments receive direction from the district engineers of the Bureau of Public Roads, and in turn direct work ofthe railroads. The highway departments award the contracts, inspect and supervise the work, and are responsible for the expenditures.

Each railroad, in the states through which it operates, carries to a conclusion with the various state highway departments the individual projects to be done on its line. The railroad organization is centralized in a National Committee on Grade Crossing Elimination of the Association of American Railroads, composed of six engineers of railroads, representative of various sections of the country, and a contact representative at Washington with the Bureau of Public Roads. The active head and chairman of the committee is R. E. Dougherty, vice president of the New York Central System. The other members are W. D. Faucette, chief engineer, Seaboard Air Line Ry., R. H. Ford, assistant chief engineer, Chicago, Rock Island and Pacific Ry., G. W. Harris, chief engineer, Atchison, Topeka and Santa Fe Railway System, W. D. Wiggins, chief engineer, Pennsylvania R. R., and R. J. Middleton, assistant chief engineer, Chicago, Milwaukee, St. Paul and Pacific R. R.

The committee coordinates the activities of the railroads by cooperation with the Bureau of Public Roads, furnishing information desired from the railroads, making suggestions as to rules and regulations applying to them, and clarifying directly with the bureau innummerable problems and questions pertaining to the railroads' participation in the work. It disseminates to the railroads information issued by the Bureau of Public Roads necessary to properly prosecute the program. In addition, in each state there is a railroad committee, composed of the chief engineers of the railroads, whose chairman maintains contact with the state highway engineer.

Prospects for the future

Under the direction of the Bureau of Public Roads, and as a part of its national survey for future highway and grade crossing planning, the railroads have joined in a co-operative effort with forty of the forty-eight states to obtain the factual data for future grade crossing elimination and protection of grade crossings. It is expected that the other eight states will join in the near future. This survey will be the basis of determining the crossings that should be eliminated by structures, those that should be eliminated by diversion of the highway, those that may remain at grade with proper protective devices, and those that may be closed entirely and traffic diverted to other crossings. Also, a general idea of the priority of the first three classifications will be had.

If we go back to the old way of financing by the railroads, states and municipalities, lack of money and lack of coordination will retard progress as in the past. The present $200,000,000 program has demonstrated that with financial aid from the federal government, and by coordinated effort, great progress can be made. The public has come to look upon the problem as being beyond the financial power of the states and the railroads, and to consider it as a job for Uncle Sam. The organization, the technical skill, the men and materials are available; the money alone is lacking. If the federal government will continue the grade crossing program from year to year, in the not-too-distant future highway-railroad grade crossings will cease to be a serious menace to highway and railroad travel.

TABLE I — RAILWAY EXPENDITURES FOR ELIMINATION AND PROTECTION OF RAILWAY GRADE CROSSINGS

Class I Railways in the United States, years 1920 to 1931

Year	Gross expenditures charged to capital account †	Amounts charged to operating expenses*		
		For maintenance and depreciation of crossings and signs	For protection of crossings	Total
1920	$7,968,865	$12,552,326	$26,413,758	$38,966,084
1921	8,089,796	10,845,325	24,842,740	35,688,065
1922	9,571,874	10,758,068	20,956,961	31,715,029
1923	11,768,868	12,571,495	21,340,703	33,912,198
1924	13,814,155	12,090,487	21,633,679	33,724,166
1925	17,547,572	12,643,427	21,499,719	34,143,146
1926	21,398,812	13,108,842	21,243,344	34,352,186
1927	30,602,050	12,948,778	21,326,114	34,274,892
1928	27,010,629	13,160,624	20,660,029	33,820,653
1929	25,703,279	14,011,399	20,125,697	34,137,096
1930	30,218,124	12,712,780	19,485,993	32,198,773
1931	19,471,591	9,732,186	18,421,023	28,153,209
Total 12 years	$223,165,615	$147,135,737	$257,949,760	$405,085,497

† From reports of railways to Bureau of Railway Economics; represents the gross cost charged to capital account for separation of grades. Costs of abandonment and removal are included for the years 1920 to 1929 but not thereafter.

* From annual reports of the Interstate Commerce Commission.

CURRENT NEWS

Injunction Against TVA Overruled in Georgia

The federal district court at Atlanta, Ga., ruled on Jan. 19 that the Tennessee Valley Authority could proceed in Georgia with its power program in spite of a temporary restraining order granted by the federal court at Nashville, Tenn. The court granted the TVA a temporary order restraining the Georgia Power Co. from enforcing the Tennessee injunction granted to nineteen utilities attacking the TVA in the Nashville court.

The decision held that the TVA had a right to a hearing in the Georgia district court on the merits of the case. The action opened the way for the TVA to sue for a permanent injunction against interference with its power activities in Georgia.

Fourteen-Lane Highway Planned On Long Island

The Long Island State Park Commission has announced that, in cooperation with the state department of public works and the New York City park department, plans have been completed for the reconstruction of the present Sunrise Highway between Laurelton Parkway and Linden Boulevard, Brooklyn, New York City. The design of this 6-mile parkway project, which is to be known as the Southern Parkway, involves the complete reconstruction, widening and landscaping of Sunrise Highway.

The plan provides for two three-lane roadways divided by a center mall and the construction of two four-lane service roadways for mixed truck and local traffic on each side of the central parkway, or fourteen lanes in all. All crossings at grade will be eliminated by bridges.

PWA Personnel Reduced

Dismissal notices, effective Jan. 31, have been sent to about 2,000 or 20 per cent, of the administrative personnel of the Public Works Administration located in Washington and in the field, thus effecting the first major reduction in the staff.

Although it has long been apparent that PWA activities are declining in volume, this is the first definite step acknowledging the fact. Administrator Ickes has stated that as the volume of work in progress gradually decreases, the administrative force attached to the agency will be progressively reduced in size. Most of the powers of PWA expire by statutory limitation June 30, 1937, and although it is hoped to secure an extension to permit the completion of important projects now under way, any definite prediction as to the future of the agency must await Congressional action.

Flood Reports on the Ohio and the Mississippi Rivers

Continued from pp. 151-155

LOUISVILLE which suffered greatest damage of all Ohio River cities.

The General Flood Picture

(*Continued from page* 151)

is estimated to be some 50 per cent greater than the one of March, 1913, which resulted in the Central States' flood disaster. An area of 100,000 sq.mi. is reported to have received 12 in. of rain during a 20-day period.

Bonnet Carre spillway was opened last week in anticipation of a flood stage, and the low head levee, or "fuseplug", of the Boeuf basin is believed to be likely to fail and submerge this basin.

Federal and state agencies have been mobilized with phenomenal rapidity and thoroughness to handle the flood emergency. CCC and WPA workers in large numbers have been thrown into the flood fighting.

Evacuation and maintenance promises to be a long-time job, as in many of the river communities people cannot safely return to their homes until spring in view of the destruction of water supplies and sanitary facilities and the tremendous magnitude of the cleanup and restoration job.

Referring to the lower Ohio, H. W. Richardson reports: "Conditions on this river are simply hell. The people simply refuse to evacuate ahead of the time of serious danger, and then the rescue load comes all at once. The army engineers stepped into this strange job of rescue and evacuation in great style. They are doing all that is humanly possible to bring order out of chaos; I have seen it happen right here today."

Flood-Beleagured Cairo

(*Continued from page* 155)

for use when the water goes down, as the pumps in their riverside pump house have been removed. Condenser water runs through their condensers and to the sewer now by gravity! The power company has met all demands, giving excellent service. The water company is operating one of its two steam pumps, which are less expensive to run than the motor driven units.

As an indication of the effect of the sheetpiles driven in the levee only 200 ft. away, Mr. Roos cited the lack of seepage through the wall of the circulating pump well, which always in former floods came through copiously. Piles 50 ft. long were driven in the levee opposite the station.

An emergency supply to two hotels from the 1000-ft. artesian wells adjacent to them has been arranged for with pipes leading to hand pumps on the second floor in one hotel and the third floor in the other. This would permit bottling to be done here in an emergency. The water rises 16½ ft. above street level from one well. A third 1000-ft. well could be utilized in a similar manner.

Water in 5-gal. bottles is being trucked to levee gangs in the Cairo Levee District. An 850-gal. tank on a trailer from the Red Cross is set at the upper end of the District. Extreme care in handling this water is observed, the attendants sterilizing the hose and nozzle and washing their hands in an alcohol bath. Rubber gloves

sterilized are also used. The bottles and tanks are so arranged that the water must be poured into cups which cannot be dipped into the container as is usually the case from the bucket of the water boy.

Other Ohio River towns

Mounds City, 5 miles upstream from Cairo, was lost on Jan. 27 due to water coming over the ring levee at the back of the city after it had come over a concrete road leading to the north (upstream) which had been erroneously considered to be at sufficiently high grade to keep out a 60-ft. crest.

Rosiclare's recently completed water supply went out of commission Jan. 26 with a full elevated storage tank of 50,000 gal. filled from the new filter plant operated behind a sandbagged station. The city is isolated, but a highway is reported as being constructed by cutting into a hillside around the low flooded section.

Golconda is mostly on high ground above dam 51 in the Ohio. The waterworks were operating, says C. W. Klassen, Illinois state sanitary engineer, by siphoning water from backwater surrounding the plant into the coagulation basin after the low-lift station had been inundated. The gasoline-engine high-lift pumps were still functioning Jan. 26.

The waterworks at Metropolis were operating Feb. 2 behind sandbagged windows and doors, with water 5 ft. over the top of the clear well. A heavy chlorine-dosage was being applied.

The Flood Fight at Paducah

(*Continued from page 152*)

all field activities. Golconda is the point of evacuation for the stretch of river above Paducah to Evansville. Major Bernard Smith, representing Col. R. G. Powell, Ohio River division engineer, is making constant surveys of the small hamlets along the river that are isolated. Some of these, he reports, are free of high water, but are cut off by backwater, others are badly flooded. Shawneetown has been evacuated; the levee was cut several days ago to avoid wash of overtopped levees.

At Golconda the Sixth Corps Area of the U. S. Army, the CCC, Red Cross and State authorities are all cooperating in taking the refugees from the Army Engineers and transporting them to established stations in the rear.

Above Cairo the work of the Army Engineers has been almost exclusively rescue and evacuation operations. The engineers have directed others in the establishment of means of access and communication facilities. There is fairly good radio communication between headquarters and principal points of operation, and there is now a direct wire to Cincinnati Division offices.

Rehabilitation of the Ohio Valley alone will require months. Damage is beyond estimate. The cost of relief of refugees will be tremendous. Greater yet will be the cost of clearing up, restoration and rebuilding. It is doubtful if many of the smaller communities can be re-occupied until May or even June. Municipal utilities are wrecked in many cases, especially waterworks, plants, sewers are collapsed and clogged. Streets soaked for days will need extensive repairs.

Pollution Control Urged at Meeting

New York State Sewage Works Association pledges support to stream pollution control legislation

Taking a definite stand on proposed federal legislation for stream pollution control, the New York State Sewage Works Association, at its ninth annual meeting in New York City, Jan. 22, adopted a resolution pledging support only to such measures as would provide for cooperation with existing state boards of health and other local agencies. A bill embodying these features is now before the Commerce Committee of the U. S. Senate (*ENR*, Jan. 21, 1937, p. 106).

Members of the association spent the first day of the three-day meeting in joint session with the sanitary engineering division of the A.S.C.E. and devoted the rest of the convention time to technical discussion and an inspection trip of the Coney Island sewage disposal plant.

The Kenneth Allen Memorial Awards for the best papers in 1936 were presented to A. J. Fischer, New York, and to George Anderson, Rockville Center, Long Island.

The importance of purification control in activated sludge plants by means of sludge activity and oxygen supply measurements was stressed in a paper by Milton Spiegel of the Chicago Pump Co., Chicago, Ill., who pointed out that careful regulation would produce power economies of 25 per cent or more.

The effect of activated carbon on sludge digestion was discussed by C. L. Walker, Cornell University, Ithaca, New York, who based his conclusions on laboratory, pilot-plant, and plant-size experiments. His work indicated that addition of powdered carbon would reduce odors, increase drainability of sludge, increase the rate of digestion at certain temperatures, and reduce gas production if the carbon was applied in larger amounts than 15 p.p.m. It was pointed out, in the discussion, by Willem Rudolfs, chief, New Jersey Sewage Experiment Station, that the low methane content indicated by the gas analyses showed that the digestion tanks were not operating properly and that conclusions must, therefore, be drawn with caution.

As a result of pilot-plant experimental work with the digestion of ground garbage, William L. Malcolm, Queens University, Kingston, Ont., Canada, stated that there should be no difficulty in digesting garbage solids either alone or mixed in any proportion with sewage sludge.

New York sewerage progress

New York City is treating only 12 per cent of its total sewage flow, but consistent progress is being made in the construction of new plants, according to Richard H. Gould, chief engineer, department of sanitation, New York City. He stated that the 180-m.g.d. Ward Island plant would be in operation at the end of 1937, that work had been started on the 40-m.g.d. Tallmans Island plant, and that the design of the 65-m.g.d. Jamaica plant was already under way. Operating experience at the Coney Island plant was described by Wellington Donaldson, sanitary engineer, department of sanitation, New York City.

Other speakers included Charles Gilman Hyde, University of California, who reviewed sewage treatment developments, and H. B. Diehl, Reeves Pulley Co., New York City, who described the use of variable speed equipment and control.

Charles C. Agar was elected president of the association, and Fred J. Biele was elected vice-president; Arthur S. Bedell remains as secretary-treasurer. Three new members were elected to the executive committee: E. J. Kilcawley of Troy, N. Y.; N. L. Nussbaumer, Buffalo, N. Y.; and Charles McBreen, Orangeburg, N. Y.

Canadian Mapping Agencies Grouped in One Department

All Canada's mapping services have been brought under one department of the government by the recent reorganization of the departments of the Interior, Mines and Immigration, and Indian Affairs in the new Department of Mines and Natural Resources.

All topographic surveying, including aerial survey work, pertaining to geological work is now under the Bureau of Geology and topography and geological mapping is under another parallel section of this bureau. All legal mapping, the preparation of aerial navigation, and tourists maps is under the surveys and engineering division of the department, as is also the geodetic survey.

Obituary

W. H. CONWELL, superintendent of the Espy Paving and Construction Company, of Savannah, Ga., died recently.

ERIC H. COSTER, an engineer for the Interboro Rapid Transit Co. of New York City, died in that city on Jan. 29 at the age of 70.

BURDET KIPP, a civil engineer for the G. O. M. Company, New York City subway builders, died recently at the age of 62. Mr. Kipp was a graduate, in 1898, of the Columbia School of Mines.

CURTIS B. BACKUS, a civil engineer employed by the Department of Justice, in charge of engineering work in connection with the construction of federal prisons, died on Jan. 14 at Alexandria, Va.

DENNIS SHEEHAN, a construction engineer who had been employed for thirty-five years, at the time of his retirement fifteen years ago, by the Central Railroad of New Jersey, died in Elizabeth, N. J., on Jan. 29 at the age of 80.

JOHN W. SEENS, president and general manager of the Canadian Bridge Company of Walkerville, Ont., Canada, died in Detroit on Jan. 25. Mr. Seens, a graduate in 1901 of the University of Michigan, joined the staff of the Canadian Bridge Company immediately after his graduation and, except for several years service as city engineer of Grand Rapids,

Mich., and with the Structural Steel Company of Montreal, has been with that company continuously ever since. He was made a director of the company in 1922, vice-president in 1926, and in 1927 he became president and general manager.

LEON L. CLARKE, secretary and treasurer of the Subway Engineering Company of Chicago, died in that city on Jan. 18 at the age of 58. Mr. Clarke, with E. A. Clark, organized the Subway Engineering Company, an engineering and contracting concern, in 1920.

WILLIAM B. JACKSON, consulting electrical and civil engineer and retired rate engineer for the New York Edison Company, died on Jan. 20, aged 66, in Pittsfield, Mass. After the completion, in 1893, of his studies at Pennsylvania State College, Mr. Jackson was engaged on the construction of power plants and transmission lines for various power companies in New York City and the Middle West. In 1902 he began the practice of consulting engineering in association with Dugald C. Jackson. Mr. Jackson, who is a member of the A.I.E.E., the A.S.M.E. and the A.S.C.E., was a past-president of the Western Society of Engineers and a sometime member of the Council of the A.S.M.E.

WILLIAM P. MASON, professor emeritus of chemistry at Rensselaer Polytechnic Institute and an authority on municipal water supply, died on Jan. 25, in Little Boar's Head, N. H., at the age of 83. Dr. Mason graduated in civil engineering from Rensselaer Polytechnic Institute in 1874 and obtained a medical degree from Union University in 1881. He had studied at the Pasteur Institute in Paris and held the degree of doctor of laws from Lafayette College. He began his teaching at Rensselaer immediately after his graduation from that institution, becoming professor of analytical chemistry in 1882 and professor of chemistry in 1893. He retired as head of the department of chemical engineering and chemistry at Rensselaer in 1925.

MELVIN D. CASLER, assistant engineer, Port of New York Authority, died in Jan. 27 in Mt. Vernon, N. Y., aged 65. Shortly after his graduation in 1906 from Union College, Mr. Casler became associated as a designer with the Board of Water Supply of New York City, remaining with that department until 1916, when he became a designing engineer for the Bronx River Parkway Commission. After several years in production engineering work, he became an assistant engineer for the New York City Board of Estimate, and in 1924 he shifted to the Hudson River Regulatory District at Albany, N. Y., as a designing engineer. Five years later he became connected with the Jersey Water Supply Commission but transferred within a few months to the Port of New York Authority, with which agency he served as assistant engineer until his death.

SOCIETY CALENDAR

ASSOCIATED GENERAL CONTRACTORS OF AMERICA, annual convention, San Antonio, Texas, Feb. 15-17.

AMERICAN CONCRETE INSTITUTE, annual meeting, New York, N. Y., Feb. 23-26.

HIGHWAY CONFERENCE, UNIVERSITY OF ILLINOIS, Urbana, Ill., March 3-5.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, annual meeting, Chicago, Ill., March 16-18.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS, annual meeting, New Haven, Conn., Feb. 16-17.

SOUTHWEST ROAD SHOW AND SCHOOL, Wichita, Kansas, Feb. 23-26.

ASSOCIATION OF HIGHWAY OFFICIALS OF NORTH ATLANTIC STATES, annual convention, New York, N. Y., Feb. 24-26.

MINNESOTA FEDERATION OF ARCHITECTURAL AND ENGINEERING SOCIETIES, annual convention, St. Paul, Minn., Feb. 26-27.

INDEX NUMBER

ENR Cost	1913 =100	1926 =100	ENR Volume	1913 =100	1926 =100
Feb., 1937	226.45	108.85	Jan., 1937	165	72
Jan., 1937	223.45	107.41	Dec., 1936	206	90
Feb., 1936	201.20	96.71	Jan., 1936	248	109
1936 (Av.)	206.46	99.24	1936 (Av.)	185	81
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50

Two Pages of Construction Charts and Tables That Ordinarily Follow This Page Will Be Published Next Week.

CONTRACTS
(Thousands of Dollars)

	Weekly Average Feb. 1936	Prev. 4 Weeks	Week Feb. 4 1937
Fed. Government	$2,468	$3,036	$4,723
State and Municipal	28,087	22,420	22,868
Total public	$30,555	$25,456	$27,591
Total private	10,570	17,813	13,860
Week's total	**$41,125**	**$43,269**	**$41,451**

Cumulative to date:
1936 (6 weeks).....$338,583,000
1937 (5 weeks).....$214,528,000

Note: *Engineering News-Record* reports waterworks and earthwork, reclamation or waterways projects of $15,000 and over in size; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the volume of contracts and large force account projects throughout the U. S. that are of these minimum sizes or over.

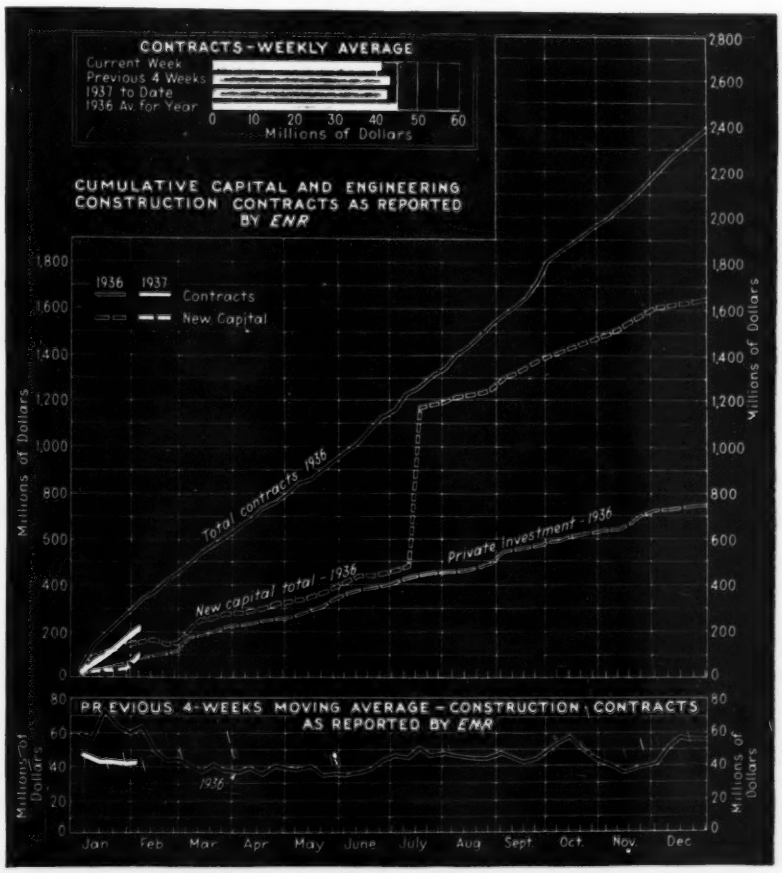
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1937	Week Feb. 4	Cumulative
Private investment	**$58,671**	**$103,262**
State and municipal bonds	6,000	48,250
Corporate securities	52,671	55,003
Federal financing	.....	**—4,061†**
PWA non-federal Projects	.....	875
Total non-federal	**$58,671**	**$104,137**
Federal projects	.....	.....
Total	**$58,671**	**$104,137**

Cumulative to date:
1936 (6 weeks).....$178,820,000
1937 (5 weeks).....$104,137,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

† Includes transfer from federal to private investment financing through sale by RFC of PWA bonds.


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1937 to Date
1936 Av. for Year
0 10 20 30 40 50 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936 1937
Contracts
New Capital
Total contracts 1936
New capital total - 1936
Private investment - 1936
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

CURRENT PRICES OF CONSTRUCTION MATERIALS

CEMENT, AGGREGATES AND READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT Per bbl., carload lots, including 40c per bbl. for bags, cash discount not included			SAND AND GRAVEL Per ton, carload lots			CRUSHED STONE Per ton, carload lots		CRUSHED SLAG Per ton, carload lots, f.o.b. plant		CONCRETE Ready Mixed 1:2:4, 50c. yd. or more, delivered
	Cloth Bags*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.83	$2.58	$2.50	$1.60	$1.60	$1.55	$1.69	$1.92	$1.69	$1.69	$8.50
Baltimore	2.46	2.21	2.01	1.80‡	1.80‡	1.30‡	1.80‡	1.80‡	1.80	1.80	7.35
Birmingham	2.40	2.15	1.95	1.80	1.80	1.45	1.00	1.00	.90	1.15	5.45
Boston	2.25*dl*	2.00*dl*	1.80*dl*	1.20	1.20	.85	1.40	1.40	....	....	7.00
Chicago	2.50	2.25	2.10	1.50	1.50	1.50	1.80	1.80	1.00	1.00	....
Cincinnati	2.47	2.22	2.02	1.20	1.20	1.30	1.80	1.80	....	....	6.70
Cleveland	2.40	2.15	....	1.40	1.40	1.10	1.60	1.60	1.75	1.75	7.40*z*
Dallas	2.30	2.05	1.85	1.40	1.40	1.05	1.10	1.15	1.84	1.89	7.00
Denver	3.08	2.85	....	1.20	1.40	.90	....	....	....	....	....
Detroit	2.25	2.00	1.80	1.30	1.30	1.20	1.50	1.60	1.40‡	1.50‡	5.95
Kansas City	2.51	2.26	2.06	1.85	1.85	1.15	1.85	1.80	....	....	7.65
Los Angeles	2.32	2.12	....	1.20	1.20	.90	1.20	1.20	....	....	6.31
Minneapolis	2.80	....	2.35	1.00*p*	1.00*p*	.25*p*	1.00*p*	1.00*p*	....	....	7.00*f*
Montreal	....	2.62*S*	1.70	.80	.85	1.00	1.20‡	1.30‡	....	....	6.50*t*
New Orleans	2.50	2.30	2.05	1.50	1.50	1.25	....	....	....	....	8.35
New York	2.35‡	2.10‡	....	1.10†*k*	1.10†*k*	.70†*k*	1.75†*k*	1.85†*k*	....	....	7.70
Philadelphia	2.55	2.30	2.10	1.45‡	1.55‡	1.15‡	2.40‡	2.55‡	1.00‡	1.00‡	8.00*D*
Pittsburgh	2.45	2.20	1.60	1.50‡	1.50‡	1.70‡	2.25‡	2.25‡	1.50	1.50	7.00
St. Louis	2.53	2.28	....	1.40‡	1.40‡	1.40‡	.75*p*	.75*p*	.65/.95§	.50/.85§	7.10
San Francisco	2.72	2.52	2.20	1.35	1.35	1.35	1.50	1.50	....	....	7.33
Seattle	2.95	2.70	....	1.33	1.33	1.33	2.25	2.25	....	....	7.50

* 10c allowed for each returnable bag. † Per cu. yd. ‡ Delivered. § F.o.b. Granite City, Ill. *k* Barge lots alongside dock. *p* F.o.b. plant. *t* 5 tons or more *z* Within 3-mi. from Public Square. *t* ton. *d* 5% discount for cash. *dl* 10% off for cash 10 days. *D* Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000. *S* Sales tax included.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Alpena, Mich.	$1.50	$1.45	Ironton, Ohio	$1.50	$1.45	North Birmingham, Ala.	$1.75	$1.70
Buffington, Ind.	1.70	1.65	Iola, Kans.	1.70	1.65	Richard City, Tenn.	1.85	1.80
Crestmore, Calif.	1.72	....	La Salle, Ill.	1.70	1.65	Saginaw, Mich.	1.40	1.35
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind.	1.70	1.65	Steelton, Minn.	1.80	1.75
Hannibal, Mo.	1.70	1.65	Mason City, Ia.	1.70	1.65	Universal, Pa.	1.65	1.60
Hudson, N. Y.	1.75	1.70	Norfolk, Va.	1.76	1.71	Waco, Tex. (Plus 5c Tax in Texas)	1.75	1.70
Independence, Kans.	1.70	1.65	Northampton, Pa.	1.65	1.60	Wyandotte, Mich.	1.45	1.40

Cash Discounts. Cement to Contractors: truck delivery, 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount, 10c. per bbl. for payment within 15 days of date of invoice.

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE—PARTITION—SCORED Per M, lots of 2,000 pieces or over,			STRUCTURAL CLAY TILE—LOAD BEARING—SCORED Per M, lots of 2,000 pieces or over,			BRICK Per M, in quantity,		LIME		
	3x12x12 in.	4x12x12 in.	8x12x12 in.	8x12x12 in.	10x12x12 in.	12x12x12 in.	Common backing	Straight hard	Per ton, Hydrated finishing	in paper, Common hydrated	carload lot, Pulverized or lump
Atlanta	$71.10	$75.80	$142.10	$170.50	$199.00	$227.40	$12.25	$15.15	$19.50	$14.00	$14.00
Baltimore	91.00	98.00	183.00	219.00	315.00	390.00	13.00	17.00	20.00	14.00	25.00
Birmingham	78.75	84.00	157.50	189.00	201.25	242.00	15.00	19.00	3.00§	1.75§	2.25*c*
Boston	87.75*sl*	93.60*sl*	175.50*sl*	198.90*sl*	210.60*sl*	258.30*s*	16.00	19.00	20.00	15.50	3.50*d*
Chicago	66.00	70.40	132.00	174.30	214.40	245.00	10.20	11.20	18.00	13.40	14.00
Cincinnati	62.00	62.80	117.75	141.30	169.26	209.56	17.50	17.50	15.20	12.30	....
Cleveland	45.00	48.00	90.00	108.00	138.50	158.50	15.00	15.00	16.00*k*	14.00*k*	2.65*kp*
Dallas	59.00	62.00	125.00	149.00	155.00	177.00	9.50	24.00	19.00	16.00	.95*r*
Denver	78.50	88.00	141.50	160.65	196.00	225.50	11.50	15.00	30.00*k*	22.00*k*	22.50*k*
Detroit	71.85	76.65	143.70	230.00	280.00	325.00	12.50	13.50	18.00	15.00	15.25
Kansas City	64.50	66.50	81.00*	125.50	159.75	186.25	13.00	22.00	18.90	12.40	10.35
Los Angeles	77.50	94.25	134.00*	188.00	232.50	311.50	11.50	14.00	18.70	....	19.70
Minneapolis	86.30	92.05	156.25	192.85	176.20*n*	245.20*n*	13.10	15.10*x*	21.00	16.00	19.00
Montreal	84.00*s*	96.00*s*	180.00*s*	.....	273.00	.....	15.50	20.75	25.50	17.00	11.00
New Orleans	69.00	69.00	129.00	155.05	203.25	251.70	13.00	.....	18.40	11.25	....
New York	78.40	83.60	125.40*	193.30†	238.80†	295.60†	12.50	.....	20.00	15.50	20.00
Philadelphia	80.50	85.90	161.10	193.30	234.40	290.10	15.00	18.00	16.10	10.90	10.40
Pittsburgh	58.40	62.30	116.85	165.00	217.00	250.00	16.50	25.00	17.20	14.50	2.22*p*
St. Louis	62.00	65.00	120.00	180.00	234.00	280.00	16.00	17.00	.55‡	.40‡	2.30*p*
San Francisco	84.00	94.50	225.00	.....	.....	.....	15.00	18.00	.55§	.40§	2.05*p*
Seattle	110.00	130.00	210.00	110.00*y*	.....	.....	20.00*d*	20.00	30.00	20.00	28.60*l*

*6x12x12 in. † F.o.b. Perth Amboy, N. J. ‡ Per sack. § Per bbl., 200 lbs. *p* Per bbl., 180 lbs. *q* Per bbl., 280-lb. *k* LCL. *d* less $1 cash 15 days. *c* Lump. *s* Smooth. *x* Selected common. *l* Carload lots delivered to job. *z* Per sack, 100 lbs. *n* - not load bearing *y* - 8 x 8 x 8 only

ROAD SURFACING MATERIALS—F.O.B. CITY

	PAVING BRICKS AND BLOCKS Granite per M, lots of 50,000, 4x4x8 in.	Brick per M, 3x4x8½ in., carload lots	Wood per sq. yd., 3½ in. 16-lb. treat	PAVING ASPHALT Per ton, less than 80 penetration, Tank car	Drums	ASPHALT BINDERS—FLUXES Per gal., 80-300 penetration, Tank car	Drums	CUTBACK ASPHALT Per ton, Tank car	Drums	ROAD OILS Per gal., Tank car	ASPHALT EMULSION Per gal., Tank car	Drums
Atlanta	$ 75.00	$35.00	$2.25	$18.20 [z]	$23.41 [z]	$0.028 [z]	$0.799 [z]	.0768† [z]	.1089† [z]	$0.668 [z]	$0.0875	$0.0875
Baltimore	110.00	44.00	2.25	17.00	22.00	.075	.10	.09†	.125†	.....	.....	.....
Birmingham	110.00	25.00	....	19.00	24.00	.0878	.1128	.10†	.137†	.....	.06	.....
Boston	75.00	46.00	3.60	17.00	22.00	.07*e*	.095*e*	.09†*e*	.125†*e*	.07*e*	.095*e*	.125*e*
Chicago	140.00	42.00	2.50	17.00	21.00	16.00	20.00	.07	.11	.045	.09	.135
Cincinnati	112.00	37.50	....	13.47	17.47	.12	.....	17.00	.....	.051	.078	.....
Cleveland	100.00‡	32.50	2.85	17.50	21.20	.075	.094	.085	.055†	.0575	.085	.095
Dallas	.....	32.50	....	18.00	21.75	.065	.16	18.75	26.25	.055	.085	.135
Detroit	.....	37.00	....	16.80*k*	21.00*k*	.....	.....	15.25	20.25	.055	.11	.15
Kansas City	.....	40.50	....	18.50	23.50	17.50‡	22.50‡	.077†	.107†	.057	.11	.15
Los Angeles	.....	50.00	....	10.00	15.16	11.00‡	15.16‡	11.00	.....	.042	.06	.12
Minneapolis	.....	.....	1.90*l*	19.90	24.70	.098	.107	21.85	34.65	.048	.....	.....
Montreal	85.00*	60.00	3.62	14.00	20.00	.10	.13	.0975†	.1125†	.0675	.135	.165
New Orleans	100.00	32.00	....	15.20	18.75	.068	.095	.075†	.10†	.....	.0785	.11
New York	120.00§	65.00	2.75	17.00	22.00	.075	.10	.09†	.125†	.....	.075	.11
Philadelphia	120.00	47.00	....	15.00	20.00	.06	.085	.065†	.095†	.055	.07	.10
Pittsburgh	115.00	40.00	....	19.00	24.00	.077	.1125	.086†	.121†	.0675	.....	.....
St. Louis	115/120	36.00	....	19.00	24.00	.0775	.1075	.0825†	.1125†	.045	.09	.12
San Francisco	.....	50.00	....	12.00	18.00	12.00‡	18.00‡	12.50‡	23.00‡	.04	.0575	.117
Seattle	.....	40.00	....	25.50	25.50	17.00‡	23.00‡	15.00	.....	.03	.19	.20

Note: Paving asphalt, tank car or boat, f.o.b. Maurer, N.J., per ton, Bermudes, $25.00; Trinidad, $21.00. *Sales tax included. †Per gallon. ‡4½x6x5½ in. #Per ton. § 4x5x9 in. Av. & Mexican. [z] Local reduction due to 20% reduction intra-state class freight rates, only Georgia affected. *l* 2½ in. 6 to 8-lb. treatment. *e* F.o.b. Everett

CURRENT PRICES OF CONSTRUCTION MATERIALS

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS	RIVETS	WIRE NAILS	SHEET PILING	STEEL RAILS (Per Gross Ton)			TRACK SUPPLIES			
		¾-in. billet	½-in. structural	Base	Base	Standard	Light	Re-rolled	Angle bars	Std. spikes	Tie plates	Track bolts
Birmingham	$2.20	$2.30	$3.35	$2.55	....	$39.00	$38.00	$37.00	$2.70	$2.90	$2.10	$4.00
Chicago	2.10	2.30	3.35	2.15	$2.50	39.00	38.00	37.00	2.70	2.90	2.10	4.00
Pittsburgh	2.05	2.25	3.25	2.40	2.40	39.00	38.00	37.00	2.70	2.90	2.10	4.00

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

F.O.B. WAREHOUSE	STRUCTURAL SHAPES Per 100 lb., base price	REINFORCING BARS Per 100 lb., ¾ in., base price		EXPANDED METAL LATH (Per 100 sq. yd., carload lots)		WELDED FABRIC REINFORCING (Per 100 s.f., carload lots)		6x6 in., No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
		New billet	Rail steel	Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	4x16 in., No. 5 & 10 wires	4x12 in., No. 8 & 12 wires		
Atlanta	$3.49	$2.54	$2.37	$21.00	$23.00	$1.63	$1.23	$0.1548	$2.70
Baltimore	3.10	2.75	2.60	25.00	28.00	1.50	1.14	.1422	2.45
Boston	3.79	2.66	2.44	23.00†	25.00†	1.56	1.18	.1476	2.82
Chicago	2.10	2.25	2.10	20.00	22.00	1.49	1.14	.1413	2.50
Cincinnati	3.65	3.40	3.40	25.01	29.50	1.48	1.13	.1404	.....
Cleveland	3.31	2.75	2.60	20.00	22.00	1.47	1.12	.1386	.....
Dallas	2.45	2.65	2.60	....	....	1.74	1.30	.1647	2.85
Denver	4.18	3.80	3.65	22.00	25.00	1.75	1.30	.1665	.....
Detroit	3.52	2.64	2.49	20.00†	22.00†	1.50	1.14	.1422	2.53
Kansas City	3.94	2.84	2.69	19.00	21.00	1.60	1.21	.1521	2.92
Los Angeles	2.35	2.325	....	23.00	27.50	1.77	1.32	.1683	2.65
Minneapolis	3.70	2.99	2.84	24.00	28.00	1.59	1.20	.1512	2.82§
Montreal	3.25	2.15	2.15	32.50	35.50	2.46	1.82	.253	2.80
New Orleans	....	....	....	20.75	23.75	1.64	1.23	.1557	.....
New York	3.62	2.68	2.53	18.50	20.50	1.53	1.16	.1449	2.73
Philadelphia	3.10	2.76	2.21	18.50	20.50	1.51	1.15	.1431	2.40
Pittsburgh	2.07½‡	1.85‡	1.90‡	20.00‡	22.00‡	1.43	1.10	.1350	2.425
St. Louis	3.69	2.59	2.44	22.00	24.00	1.50	1.13	.1422	2.35
San Francisco	3.65	2.725	2.575	24.50	26.50	1.77	1.31	.1683	3.00
Seattle	3.55	3.00	....	25.00	30.00	1.77	1.31	.1683	2.60

‡Base Mill Price plus switching charge. Note: Shapes, bars and piling subject to quantity discounts. §Mill Price plus freight to Minneapolis. ††f.o.b. delivered.

PAINTING AND ROOFING SUPPLIES—F.O.B.

	RED LEAD Per 100 lb. in 500-lb. lots Dry	WHITE LEAD Per 100 lb. in 500-lb. lots # in oil	READY-MIXED PAINT Per gal., drums			ROOFING SUPPLIES Carload lots, f. o. b. factory				
			Graphite*	Aluminum†	Ferric Oxide‡	Rolls, slate surfaced, 85-90 lb., per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating per gal.	Tar pitch, 350 lb. bbl., per ton
Atlanta	$7.75	$11.375	$1.60	$2.50	$1.40	$1.94	$1.70	$1.70	$.36	$25.60
Baltimore	7.00	11.00	1.45	2.25	1.70	2.03	3.00	3.00	.35	25.00
Birmingham	7.25	11.375	2.35	2.35	1.85	2.01	1.77	1.77	.36	22.00
Boston	7.00	11.00	1.80	2.50	.0475x	1.75	2.25k	2.25k	.45	20.00
Chicago	7.00	11.00	1.80	....	....	2.48	2.37	2.37	.43	33.00
Cincinnati	7.00	11.00	1.45	2.50	1.40	2.40	2.39k	2.39k	.36	21.00
Cleveland	7.00	11.00	1.70	2.45	1.40	1.55	1.75k	1.75k	.23	19.00
Dallas	7.25	11.75	1.80	2.10	....	2.75k	2.50k	2.50k	.60	60.00
Denver	7.50	11.50	2.55	....	....	2.25	3.55	3.55	.35	30.00
Detroit	7.00	11.00	1.65	2.40	1.40	2.40	2.65	2.50	.35	30.00
Kansas City	7.00	11.12½	1.65	2.65	1.10	1.78	3.15	3.15	.25	24.50
Los Angeles	7.25	11.75	1.60	2.25	2.30	2.00	1.50	....	.45	....
Minneapolis	7.00	11.12½	....	....	....	1.75v	1.62kv	1.62kv	.29	23.80
Montreal	....	8.20	2.00	4.75	2.40	2.50	1.60	1.83	.50	1.52§
New York	7.00	11.00	1.85	2.50	1.55	1.75	1.62k	1.62k	.232	22.00
Philadelphia	7.00	11.00	2.515	2.94	1.515	1.75	1.86k	1.48k	.29	25.00
Pittsburgh	7.00	11.00	1.05	1.95	.80	1.90	1.82k	1.82	.34	20.00
St. Louis	10.00	11.00	1.60/1.85	2.40/2.45	1.40/1.70	1.83k	2.57	2.57	.25	25.00
San Francisco	7.25	11.50	1.80	2.75	1.10–2.00	1.54	1.90	1.90	.325	22.00
Seattle	7.25	11.75	1.80	2.85	2.20	1.97	2.42	2.60	.60	28.00

*U. S. War Dept. Spec. 3–49A. †ASTM Spec. D266–31. ‡80% maximum ferrie oxide. §Per 100 lb. kPer roll, 65 lb. xPer lb. vMinneapolis & vicinity. Note: Red lead in oil 50c higher than white lead in oil. #Basis of quoting changed this month from list to 500-lb. lots. @Sales Tax included.

MISCELLANEOUS ITEMS

WINDOW GLASS

Discounts from latest jobbers List, Sept. 15, 1928

Single or Double Thickness

	A quality	B quality
Atlanta	75%	75%
Baltimore	84%	86%
Birmingham	88%	90%
Boston	87%	88%
Chicago	85%	86%
Cincinnati	89–10%	91–10%
Cleveland	85%	85%
Dallas	80%	80%
Denver	84%	85%
Detroit	87–10%	89–10%
Kansas City	82–10%	83–10%
Los Angeles	90%*	90–40%
Minneapolis	83%	84%
Montreal	60–30%	70–5%
New Orleans	88%	90%
New York	85%	87%
Philadelphia	85%	86%
Pittsburgh	85%	85%
St. Louis	89%	89%
San Francisco	78%	83%
Seattle	85%	86%

*Disc. from list Aug. 1, 1929. †F.o.b. Arsenal. ‡Double thickness A & B. xManhattan only – other Boroughs $6 per trip. c carload lots.

EXPLOSIVES

Per lb. dynamite delivered 50-lb. cases

	Gelatin 40%	Gelatin 60%
Atlanta	$0.15	$0.165
Baltimore	.45	.16
Birmingham	.095	.11
Boston	.13	.145
Chicago	.105c	.12c
Cincinnati	.27	.29
Cleveland	.215	.225
Dallas	.16	.170
Denver	.15	.16
Detroit	.21	.24
Kansas City	.15	.165
Los Angeles	.1725†	.1925†
Minneapolis	.145	.16
Montreal	.18	.1925
New Orleans	.215	.23
New York	.215x	.23x
Philadelphia	.145	.16
Pittsburgh	.1325	.1475
St. Louis	.145	.165
San Francisco	.1475	.1625
Seattle	.1425	.1575

CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York.

Bleaching powder, in drums, F.o.b. works, per 100-lb.	$2.00–2.85
Calcium chloride, 77–80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, f.o.b. works, freight equalized with points of competition, per ton	22.00–35.00
Chlorine cylinders, per lb. delivered	.055
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb.	1.35
Soda ash, 58%, in paper bags, per 100 lb dense	1.25
Sulphate of aluminum, commercial, in 100-lb. bags, per ton	27.00
Sulphate of copper, in bbl., per 100-lb.	4.85

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf Barge	Short Leaf Rail	Long Leaf Barge	Long Leaf Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.16	$0.195	$0.16	$0.19
12 in.—2 ft. from butt.	6 in.	50 to 59 ft.	.20	.24	.18	.23
12 in.—2 ft. from butt.	6 in.	60 to 69 ft.	.21	.255	.19	.24½
14 in.—2 ft. from butt.	6 in.	50 to 69 ft.	.23	.265	.23½	.27½
14 in.—2 ft. from butt.	6 in.	70 to 79 ft.	.25	.275	.27½	.33½
14 in.—2 ft. from butt.	5 in.	80 to 85 ft.	.37	.415	.....	.....
14 in.—2 ft. from butt.	5 in.	85 to 89 ft.	.40	.482	.....	.....

RAILWAY TIES

Prices f.o.b., per tie, for carload lots:

		6 In. x 8 In. by 8 Ft.	7 In. x 9 In by 8½ Ft.
Boston	Oak, untreated	$1.10	$1.50
	Pine, untreated	1.10	1.50
	Pine, creosoted	1.60	2.25
New York	Long-leaf sap pine, untreated	1.05	1.25
	Mixed oak, untreated	1.20	1.40
	White oak, untreated	.85	1.35
	White oak, creosoted	1.50	1.70
Birmingham	Southern pine, untreated *6 x 8 x 8' 6"	.55*	.70
	Southern pine, creosoted	1.10*	1.30
	White oak, untreated	1.25	1.55
	Oak, empty cell, creosoted	1.67	2.05
Chicago	Oak, zinc treated	1.55	1.90
	Southern pine, creosoted	1.50	1.95
Los Angeles	Fir, untreated	.50	.72
	Fir, creosoted	1.67	2.40
Philadelphia	Red oak, untreated	1.00	.....
	Red oak, creosoted	.....	2.10
	White oak, untreated	1.20	1.50
St. Louis	Red oak, untreated	1.15	1.40
	Red oak, creosoted	1.50	2.15
	Sap pine or cypress, untreated	1.00	1.20
San Francisco	Douglas fir, green, untreated	.65	.63
	Douglas fir, empty cell, creosoted	1.14	2.25
Montreal	Birch or maple, untreated	.65	.75
	Birch or maple, creosoted	1.05	1.35

CURRENT PRICES OF CONSTRUCTION MATERIALS

PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

	C. I. PIPE	VITRIFIED SEWER PIPE				CLAY DRAIN TILE		CONCRETE SEWER PIPE		WROUGHT STEEL PIPE — Full standard weight, ‡			
	Per net ton, f.o.b. 6 in. to 24 in.*	Per foot, delivered, ASTM C 13-35 8 in., s.s.	12 in., s.s.	24 in., d.s.	36 in., d.s.	Per 1,000 ft., carload lots., f.o.b. 6 in.	8 in.	Per ft., delivered; ASTM C 14-35 12 in.	24 in.	1 to 3 in., Butt Weld Black %	Galv. %	3½ to 6 in., Lap Weld Black %	Galv. %
Atlanta	$45.00	0.26dl	$0.468dl	$1.629	$4.501	$85.00	$128.00	$0.45	$1.625	49.5	40.5	47	37.5
Baltimore	48.50	.28	.54	2.38	7.18	110.00	170.00	.40	1.60	.....	.....	.....	.....
Birmingham	41.00	.25	.45	1.625	4.66	85.00	220.00	.40	1.60	69.5	61.5	62	58.5
Boston	48.50	.224	.432	1.98	5.845	99.00	153.00	.43	2.40	.....	.....	.....	.....
Chicago	49.50	.245	.4725	2.025	4.60	60.00	120.00	.36	1.42	58.75	48.75	55.625	45
Cincinnati	48.00	.189	.3645	1.62	5.535	69.00	108.00	.40	1.40	58.75	48.75	55.625	45.00
Cleveland	49.50	.182	.351	1.53	4.8175	69.00	108.00	.32	1.64	61	51	57.9	47.25
Dallas	53.00	.40	.....	.....	.....	160.00	260.00	.46	1.57	69.5	61.5	67	58.5
Denver	61.00	.27‡	.47‡	1.98‡	.....	105.00	180.00	.....	.....	50	40	47	36
Detroit	49.50	.203	.3915	1.71	5.2375	82.00	136.00	.35	1.20	59.3	49.3	56.1	45.5
Kansas City	51.00	.30	.54	2.16	5.00	120.00	140.00	.40	1.50	55	45	52.0	41.5
Los Angeles	49.50	.2825‡	.508‡	2.03‡	5.535‡	115.50	192.50	1.00	2.00	62.1	54.1	59.6	51.1
Minneapolis	51.50	.24‡	.432‡	1.728‡	4.60‡	.....	.....	.65	1.75	.....	.....	.....	.....
Montreal	50.00	.33‡	.59‡	2.04‡	.....	82.00	134.00	.51	2.04	.....	.....	.....	.....
New Orleans	47.00	.23	.41	1.60	.....	67.00	.....	.47	1.67	.....	.....	.....	.....
New York	48.00	.24	.49	2.20	6.10	.....	.....	.55	2.00	57.50s	47.50s	54.375s	43.75s
Philadelphia	45.00	.196	.378	1.755	5.33	100.00	150.00	.54	1.80	52.37s	41.35s	53.39s	42.57s
Pittsburgh	51.00	.168‡	.324‡	1.35‡	4.92‡	52.00	81.00	.75c	1.75	69.5	61.5	67	58.5
St. Louis	48.80	.28	.504	2.016	3.96	85.00	170.00	1.00	2.25	57.125	47.125	54	43.375
San Francisco	49.00	.29L	.522L	2.088L	5.67L	103.50	172.50	.45	2.20	59.	49	52	41
Seattle	50.50	.420	.63†	3.06†	7.55†	85.00	200.00†	.50†	1.60	65.80	57.25	66.75	56.30

* b. & s. class B and heavier, C/L lots, 200 tons and over. Burlington, N. J. (base) $45.00. Gas pipe and class A, $3 per ton additional, 4 in., $3 per ton additional. 30 in. and larger usually $2 per ton less.

‡ Discounts from standard list for delivery from warehouse, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¼ in., 8½c.; ⅜ in. 11½ c.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½ c.; 4 in., $1.09; 6 in., $1.92.

s Resale price to consumer, car load lots shipped from mill.

f.o.b. † Less 30% in C/L Lots. c Concrete Culvert pipe reinforced. d Double strength. l List to dealers. L list. t Sales & municipal taxes extra.

LUMBER AND TIMBER—PER M FT. B.M., CARLOAD LOTS F.O.B.

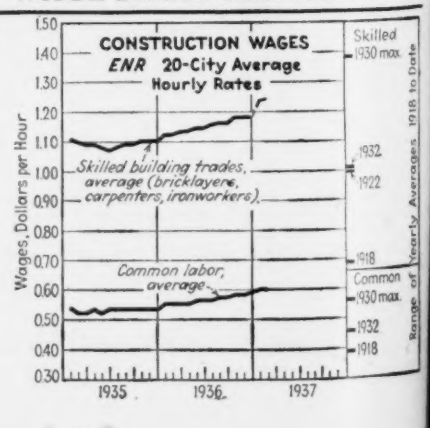
	SHORT LEAF YELLOW PINE AND DOUGLAS FIR — All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. (Prices in Bold Face). *All Fir planks No. 2 common; Fir timber is No. 1 common. Lengths up to 20 ft. (Prices in italics)*									LONG LEAF Y. P. Merchantable grade up to 20 ft.		PLYWOOD Rail freight increment (See note)	
	1x6,§	1x8,§	2x4,§	2x6,§	2x8,§	2x10,§	3x12,#	6x12,#	12x12,#	2x12,#	12x12,#	⅜"	¼"
Atlanta	$22.00	$22.00	$22.50	$22.00	$22.50	$25.00	$30.00	.....	.....	$50.00	$50.00	$16.80	$20.50
Baltimore	25.50	26.00	28.50	27.50	29.00	33.50	41.00	.....	.....	58.00	59.00	16.45W	20.05W
	32.00	*32.00*	*31.00*	*30.50*	*30.50*	*31.00*	*33.50*	*$35.50*	*$34.00*	.....	.....	.....	.....
Birmingham	24.00	24.00	27.00	25.00	26.50	35.00	36.00	35.00	35.00	.....	.....	15.55	18.95
[1]	25.00	25.00	32.00	30.00	32.00	42.00	48.00	.....	.....	48.00	50.00	.....	.....
Boston	32.00[2]	32.00[2]	35.00[2]	35.00[2]	51.00[1]	60.00[1]	75.00[1]	.....	.....	75.00	75.00	16.45W	20.05W
	32.00	*32.00*	*35.00*	*35.00*	*40.00*	*40.00*	*45.00*	*48.00*	*48.00*	.....	.....	.....	.....
Chicago	34.00	35.00	34.00	33.00	34.00	34.00	50.00	.....	.....	60.00	60.00	12.45	15.15
Cincinnati	25.50	25.50	25.50	24.50	25.50	28.50	39.50	.....	.....	41.00	44.00	15.55	18.95
	.....	.....	.....	.....	.....	.....	*43.75*	*43.75*	*43.75*	.....	.....	.....	.....
Cleveland	30.00	32.00	38.00	32.00	36.00	38.00	49.00	*44.00*	*43.75*	52.00	64.00s	15.55	18.95
Dallas [d]	37.50	39.00	40.00	40.00	41.00	42.50	61.50	*76.50*	*66.50*	62.65	76.50	13.15	16.05
Denver [w]	*42.00*	42.00[4]	*43.00*	*43.00*	*43.00*	*47.00*	*52.00*	*56.00*	*61.50*	.....	.....	9.35	11.35
Detroit	30.00	30.00	30.00	30.00	30.00	31.00	39.00	.....	.....	32.00	44.00	15.55	18.95
	.....	.....	.....	.....	.....	.....	*47.50*	*47.50*	*52.00*	34.00	46.00	.....	.....
Kansas City	29.00	29.00	27.00	26.50	27.50	28.00	37.00	.....	.....	52.00	60.00	11.45	13.95
	28.00	*28.00*	*29.00*	*28.00*	*29.00*	*29.00*	*35.00*	*38.00*	*38.00*	.....	.....	.....	.....
Los Angeles [†]	*37.00*	*36.00*	*37.00*	*36.00*	*38.00*	*38.00*	*40.00*	*51.00*	*46.00*	.....	.....	8.90WX	10.80WX
Minneapolis [*‡]	45.00[6]	51.50[6]	50.00[6]	41.00[6]	41.00[6]	42.00[6]	.....	.....	.....	58.00[6]	.....	11.45	13.95
[*]	*42.00*	*42.00*	*43.00*	*43.00*	*43.00*	*43.00*	*55.00*	*59.50*	*59.50*	54.00	.....	.....	.....
Montreal [7]	45.00	45.00	49.00	47.00	48.00	58.00	.....	.....	.....	.....	.....	.....	.....
	39.50	*39.50*	*40.00*	*40.00*	*40.00*	*41.50*	*42.00*	*42.00*	*42.00*	82.00	76.00	.....	.....
New Orleans	23.50	25.50	28.00	25.00	27.00	25.50	38.00	.....	.....	44.00	54.00	13.15	16.05
	28.50	*30.00*	*33.00*	*29.00*	*32.00*	*33.50*	*37.00*	.....	.....	.....	.....	.....	.....
New York [*]	37.50	39.00	37.50	39.00	39.00	42.00	47.50	.....	.....	80.00	85.00	16.45W	20.05W
[*]	.....	.....	*46.00*	*46.00*	*46.00*	*46.00*	*50.00*	*57.50*	*57.50*	.....	.....	.....	.....
Philadelphia	28.50	23.50	28.50	29.00	29.50	30.50	38.50	.....	.....	60.00	60.00	16.45W	20.05W
	45.00	*45.00*	*45.00*	*45.00*	*45.00*	*45.00*	*45.00*	*42.00*	*42.00*	.....	.....	.....	.....
Pittsburgh	38.10	39.90	47.05	42.00	45.65	46.50	59.70	.....	.....	57.50	57.50	16.20	19.70
	51.90	*49.60*	*49.60*	*49.00*	*48.90*	*49.25*	*66.55*	*66.55*	*66.55*	.....	.....	.....	.....
St. Louis [*§]	31.50	35.50	34.00	33.00	34.00	35.00	48.50	*55.00*	*55.00*	72.00	71.00	13.15	16.05
San Francisco. [$]	*22.00*	*22.00*	*22.50*	*22.50*	*22.00*	*22.50*	*25.50*	*22.00*	*22.00*	.....	.....	6.95W	8.50W
Seattle	*16.50*	*16.50*	*16.50*	*15.50*	*15.50*	*15.50*	*21.00*	*20.00*	*20.00*	.....	.....	0.00	0.00

§ S4S. # Rough. * All prices delivered. † Yard prices. ‡ Contractors in Minneapolis & St. Paul get 15% disc. from list. § 5M ft. or less. $ At ship's tackle. d10% Disc. taken off. 1 Long leaf. 2 Roofers N.C. Pine. 3 Spruce. 4 Native. 5 Northern Pine. 6 Western Pine. 7 Pine. 8 Norway Pine. *Dec. prices, Jan. prices not available due to strike. Bold face type, Southern Pine. Italics, Douglas Fir.

Note: Special concrete form grade PLYWOOD, 4'x8' panels, 5-ply, sanded 2 sides, water resistant glue, car load lots, delivered per 1000 sq.ft. surface. Base price — Seattle: ⅜", $63.75; ¾", $72.75. For other centers add rail freight increment from table for proper size.

W Lower rate by water shipment. X 50,000 lb. minimum.

CURRENT BUILDING AND CONSTRUCTION WAGE RATES PER HOUR

	Bricklayers	Carpenters	Structural Iron Workers	Hoisting Engineers	Plasterers	Common Labor — Building	Common Labor — Heavy Const.
Atlanta	$1.125	$0.40/1.00	$1.25	$1.00/1.25	$1.00	$0.30/.40	$0.30/.40
Baltimore	1.25	1.10	1.375	1.25	1.25	.45	.45
Birmingham	1.00	1.00	1.25	1.125	1.00	.30/.40†	.30/.40†
Boston	1.50	.90/1.375	1.375	1.00/1.375	1.625	.60/.80	.60/.85
Cincinnati	.80/1.375	.65/1.20	1.25	1.00/1.25	.80/1.375	.45	.45
Chicago	1.50	1.50	1.50	1.50	1.50	.95	.95
Cleveland	1.375	1.25	1.25	1.25	1.50	.825	.825
Dallas	1.25	1.00	1.00	1.00	1.25	.40	.40
Denver	1.25	1.25	1.25	.....	.....	.625	.625
Detroit	1.25	1.00	1.25	1.25	1.25	.60/.75	.60/.75
Kansas City	1.325	1.25	1.25	1.25	1.45	.80	.45/.50
Los Angeles	1.10	1.10	1.125	1.125	1.25	.60	.60
Minneapolis	1.25	1.10	1.25	1.25	1.35	.75	.75
New Orleans	1.00	.75	1.00	1.00	1.25	.30/.40	.30/.40
New York	1.50	1.40	1.65	1.50/1.65	1.50	.825	.50/.80
Philadelphia	1.50	1.00	1.375	1.50	1.375	.40/.50	.40/.50
Pittsburgh	1.50	1.25	1.375	1.00	1.50	.70	.50
St. Louis	1.50	1.25	1.75	1.57/1.75	1.50	.7875	.35/.7875
San Francisco	1.50	1.125	1.375	1.125	1.50	.75	.60
Seattle	1.50	1.125	1.25	1.25	1.50	.80	.80
Montreal	.70	60	.65	.55	.70	.40	.35

Skilled Avg.: (Bricklayers, Carpenters, Ironworkers) $1.244; Common Avg. $0.603. † PWA.